State of New York — Department of Agriculture.

Twenty-First Annual Report

of the

BOARD OF CONTROL

of the

New York Agricultural Experiment Station

(GENEVA, ONTARIO COUNTY).

FOR THE YEAR 1902

With Reports of Director and Other Officers.

TRANSMITTED TO THE LEGISLATURE JANUARY 15, 1903.

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STATE OF NEW YORK.

No. 64.

IN ASSEMBLY,

JANUARY 15, 1903.

TWENTY-FIRST ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station.

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, *January* 15, 1903.

To the Assembly of the State of New York:

I have the honor to herewith submit the Twenty-first Annual Report of the Director and Board of Managers of the New York Agricultural Experiment Station at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

CHARLES A. WIETING,

Commissioner of Agriculture.

NEW YORK AGRICULTURAL EXPERIMENT STATION,

W. H. JORDAN, *Director.*

GENEVA, N. Y., *January* 15, 1903.

Hon. CHARLES A. WIETING, *Commissioner of Agriculture, Albany, N. Y.:*

DEAR SIR.— I have the honor to transmit herewith the report of the Director of the New York Agricultural Experiment Station for the year 1902.

Yours respectfully,

S. H. HAMMOND,

President, Board of Control.

1902.

ORGANIZATION OF THE STATION.

BOARD OF CONTROL.

GOVERNOR BENJAMIN B. ODELL, JR., Albany.
STEPHEN H. HAMMOND, Geneva.
FREDERICK C. SCHRAUB, Lowville.
LYMAN P. HAVILAND, Camden.
EDGAR G. DUSENBURY, Portville.
OSCAR H. HALE, North Stockholm.
MARTIN L. ALLEN, Fayette.
JENS JENSEN, Binghamton.
THOMAS B. WILSON, Halls Corners.
EDWARD A. CALLAHAN, Albany.

OFFICERS OF THE BOARD.

STEPHEN H. HAMMOND, *President.*

WILLIAM O'HANLON, *Secretary and Treasurer.*

EXECUTIVE COMMITTEE.

STEPHEN H. HAMMOND,
FREDERICK C. SCHRAUB,
LYMAN P. HAVILAND,
——— ———,
THOMAS B. WILSON.

STATION STAFF.

WHITMAN H. JORDAN, SC. D., *Director.*

GEORGE W. CHURCHILL, *Agriculturist and Superintendent of Labor.*

WILLIAM P. WHEELER, *First Assistant (Animal Industry).*

FRED C. STEWART, M.S., *Botanist.*

HARRY J. EUSTACE, B.S., *Assistant Botanist.*

LUCIUS L. VAN SLYKE, PH.D., *Chemist.*

*WILLIAM H. ANDREWS, B.S.,
†CHRISTIAN G. JENTER, PH.C.,
¶J. ARTHUR LE CLERC, B.S.,
FREDERICK D. FULLER, B.S.,
EDWIN B. HART, B.S.,
*CHARLES W. MUDGE, B.S.,
†ANDREW J. PATTEN, B.S., *Assistant Chemists.*

HARRY A. HARDING, M.S., *Dairy Bacteriologist.*

**LORE A. ROGERS, B.S.,
JOHN F. NICHOLSON, M.S., *Assistant Bacteriologist.*

GEORGE A. SMITH, *Dairy Expert.*

FRANK H. HALL, B.S., *Editor and Librarian.*

VICTOR H. LOWE, M.S., *Entomologist*

¶¶PERCIVAL J. PARROTT, A.M.,
HOWARD O. WOODWORTH, M.S., *Assistant Entomologist.*

SPENCER A. BEACH, M.S., *Horticulturist.*

§NATHANIEL O. BOOTH, B.AGR.,
VINTON A. CLARK, B.S., *Assistant Horticulturist.*

ORRIN M. TAYLOR, *Foreman in Horticulture.*

‡F. ATWOOD SIRRINE, M.S., *Special Agent.*

FRANK E. NEWTON,
JENNIE TERWILLIGER, *Clerks and Stenographers.*

ADIN H. HORTON, *Computer.*

Address all correspondence, not to individual members of the staff, but to the NEW YORK AGRICULTURAL EXPERIMENT STATION, GENEVA, N. Y.

The Bulletins published by the Station will be sent free to any farmer applying for them.

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*Connected with Fertilizer Control. †Absent on leave. ‡In Second Judicial Department. ¶Resigned August 17, 1902. **Resigned July 1, 1902. §Resigned August 5, 1902. ¶¶Resigned August 1, 1902.

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TWENTY-FIRST ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station.

TREASURER'S REPORT.

GENEVA, N. Y., *October* 1, 1902.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending September 30, 1902.

APPROPRIATION 1901–1902.

GENERAL EXPENSES.

Receipts.

1901.			
Oct. 1.	To balance		$3,711 57
	To amount received from Comptroller	$12,000 00	
	To amount due from Comptroller	4,000 00	
			16,000 00
			$19,711 57

Expenditures.

		By building and repairs	$2,014 90
		By chemical supplies	921 74
		By contingent expenses	1,380 75
		By feeding stuffs	676 48
		By fertilizers	416 02
		By freight and express	583 15
		By furniture and fixtures	483 98
		By heat, light and water	2,687 09
		By library	599 02
		By live stock	176 00
		By postage and stationery	387 50
		By publications	1,606 04
		By scientific apparatus	36 69
		By seeds, plants and sundry supplies	1,532 36
		By tools, implements and machinery	577 62
		By traveling expenses	1,037 94
1902.			
Oct.	1.	By balance	4,594 29
			$19,711 57

SALARIES.

Receipts.

APPROPRIATION 1901–1902.

1901.				
Oct.	1.	To balance		$6,788 59
		To amount received from Comptroller	$16,500 00	
		To amount due from Comptroller	5,500 00	
				22,000 00
				$28,788 59

Expenditures.

1902.			
		By salaries	$23,380 51
Oct.	1.	By balance	5,408 08
			$28,788 59

LABOR.

Receipts.

APPROPRIATION 1901–1902.

1901.				
Oct.	1.	To balance		$3,246 81
		To amount received from Comptroller	$9,000 00	
		To amount due from Comptroller	3,000 00	
				12,000 00
				$15,246 81

Expenditures.

1902.			
		By labor	$11,810 78
Oct.	1.	By balance	3,436 03
			$15,246 81

COMMERCIAL FERTILIZERS.

Receipts.

APPROPRIATION 1901–1902.

1901.				
Oct.	1.	To balance		$2,207 16
		To amount received from Comptroller	$7,500 00	
		To amount due from Comptroller	2,500 00	
				10,000 00
				$12,207 16

Expenditures.

By chemical supplies	$218 08
By contingent expenses	2 55
By freight and express	90 66
By furniture and fixtures	4 00
By heat, light and water	291 37
By postage and stationery	25 99

		By publications		$1,842 05
		By salaries		5,061 93
		By seeds, plants and sundry supplies		94 59
		By tools, implements and machinery		60
		By traveling expenses		897 59
1902.				
Oct.	1.	By balance		3,677 75
				$12,207 16

CONCENTRATED FEEDING STUFFS INSPECTION.

Receipts.

APPROPRIATION 1901–1902.

1901.				
Oct.	1.	To balance		$270 22
		To amount received from Comptroller	$2,100 00	
		To amount due from Comptroller	400 00	
				2,500 00
				$2,770 22

Expenditures.

		By contingent expenses	$0 75
		By freight and express	29 45
		By postage and stationery	4 95
		By publications	820 98
		By salaries	1,347 06
		By seeds, plants and sundry supplies	16 96
		By traveling expenses	240 74
1902.			
Oct.	1.	By balance	309 33
			$2,770 22

SECOND JUDICIAL DEPARTMENT.

APPROPRIATION 1901–1902.

Receipts.

1901.			
Oct. 1.	To balance		$1,620 48
	To amount received from Comptroller	$7,158 42	
	To amount due from Comptroller	841 58	
			8,000 00
			$9,620 48

Expenditures.

	By contingent expenses	$37 35
	By fertilizers	12 20
	By freight and express	13 85
	By heat, light and water	20 91
	By labor	404 38
	By postage and stationery	6 83
	By publications	1,320 09
	By salaries	4,140 54
	By scientific apparatus	5 80
	By seeds, plants and sundry supplies	133 60
	By tools, implements and machinery	69 60
	By traveling expenses	739 27
	By rents	254 00
1902.		
Oct. 1.	By balance	2,462 06
		$9,620 48

DIRECTOR'S HOUSE.

APPROPRIATION 1900–1901.

Receipts.

To amount received from Comptroller	$4,456 76

Expenditures.

To construction director's house	$4,456 76

REPAIRS TO OFFICE BUILDING.

APPROPRIATION 1901–1902.

$8,500.00.

Receipts.

		To amount received from Comptroller...	$86 00

Expenditures.

		By construction	$86 00

INSURANCE MONEY.

1902.

Receipts.

		To amount received for insurance on barns	$12,863 52

Expenditures.

		By building and repairs...............	$3,728 20
		By feeding stuffs.....................	202 14
		By tools, implements and machinery....	391 98
1902.			
Oct.	1.	By balance	8,541 20
			$12,863 52

FERTILIZER LICENSE.

1901–1902.

Receipts.

		To amount received for fertilizer licenses.	$11,640 00

Expenditures.

		By amount remitted to Treasurer, State of New York......................	$11,640 00

FEEDING STUFFS LICENSE.

1901–1902.

Receipts.

		To amount received for feeding stuffs licenses..........................	$3,275 00

Expenditures.

By amount remitted to Treasurer, State of New York	$3,275 00

All expenditures are supported by vouchers approved by the auditing committee of the Board of Control and have been furnished the Comptroller of the State of New York.

THE UNITED STATES APPROPRIATION, 1901–1902.

Receipts.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1902, as per Act of Congress approved March 2, 1887	$1,500 00

Expenditures.

By publications	$1,187 75
By postage and stationery	33 10
By chemical supplies	19 60
By library	2 00
By furniture and fixtures	75 00
By traveling expenses	37 66
By contingent expenses	144 89
	$1,500 00

WILLIAM O'HANLON,
Treasurer.

DIRECTOR'S REPORT FOR 1902.*

To the Honorable Board of Control of the New York Agricultural Experiment Station:

GENTLEMEN.— I have the honor to present herewith the proceedings of the institution under your charge during the year 1902.

It is gratifying to be able to report a year of continued prosperity in what pertains to the essentials of successful experiment station effort. The result of experiments and investigations included in this report are highly satisfactory. There is, so far as I can learn, a continued relation of good will and cooperation with the farmers of the State and the finances of the institution have been adequate in most respects to all pressing needs.

THE STATION STAFF.

An unusual number of changes in the Station staff have occurred during the year. Several members of the staff, in no case the head of a department, after longer or shorter periods of faithful service, have been called to more responsible positions in other institutions; and it should be a matter of pride that these gentlemen are meeting with success in their new work.

Under the new arrangement outlined in my report for 1901, Mr. F. A. Sirrine closed his connection with the Station as Entomologist on July 1, 1902, and became special agent of the Station in assisting in the experiments and investigations in the Second Judicial Department.

Mr. P. J. Parrot, Assistant Entomologist, resigned on August 1 to accept the position of Entomologist to the Ohio Agricultural Experiment Station. In accordance with the requirements of the Civil Service Rules, H. O. Woodworth, M. S., was appointed on July 15 to fill this vacancy. Mr. Woodworth graduated from

* A reprint of Bulletin No. 229.

the University of Illinois in the class of 1892 and subsequently pursued post graduate studies at Cornell University.

N. O. Booth, Assistant Horticulturist, resigned on August 5 to accept the position of Horticulturist at the Washington State College.

A special examination for the purpose of filling this position was requested of the Civil Service Commission, which resulted in the appointment, on October 15, of Vinton A. Clark, B. S. Mr. Clark graduated from the University of Vermont in 1898 and was for a time since connected with the Office of Experiment Stations at Washington.

J. A. Le Clerc, who was granted a year's leave of absence from September 15, 1901, resigned on August 17 in order that he might spend a second year in advanced study. The Civil Service Commission was requested to hold a special examination for filling the vacancy, but as the only candidate who was regarded as competent to fill the place accepted another position before I was able to communicate with him, the vacancy remains unfilled.

Lore A. Rogers, Assistant Bacteriologist, resigned on July 1 to accept a position in the Dairy Division of the U. S. Department of Agriculture. Acting under the Civil Service Rules, John F. Nicholson, M. S., was appointed on June 1 from the eligible list to fill the vacancy. Mr. Nicholson received his under graduate degree from the University of Wisconsin and remained for two years at that institution pursuing special studies in bacteriology.

In accordance with a vote of your Board authorizing such action, H. J. Eustace, B. S., after a special examination was held by the Civil Service Commission, was appointed on June 1 to the position of Assistant Botanist. Mr. Eustace is a graduate of the Michigan Agricultural College and was for one year a student assistant at the New York Agricultural Experiment Station.

Mr. C. G. Jenter, Assistant Chemist, because of ill-health, was necessarily granted a year's leave of absence from November 1, 1902, and Mr. A. J. Patten, Assistant Chemist, was granted a leave of absence for one year from September 1, 1902.

DESTRUCTION BY FIRE OF BUILDINGS AND OTHER PROPERTY.

A fire, the origin of which is not known, occurred at the New York Agricultural Experiment Station on May 7, 1902, and destroyed several buildings — a cattle barn, horse barn and carriage house, a barn for storage of machinery and other materials, and two poultry houses. All farm machinery and some other property was also burned. This loss rendered necessary the erection of new buildings and incidentally demonstrated the present defenseless condition of the institution against such disasters in the future.

The sums received from insurance on the property burned were as follows:

Buildings	$10,500 00
Hay and grain	438 50
Cattle	425 00
Machinery	1,500 00
Total	$12,863 50

A ruling of the Comptroller allowed the immediate use of this money for replacing, in so far as possible, the buildings and other property.

NEW BUILDINGS AND OTHER NEEDS.

New buildings.—A new cattle barn of the most approved construction, and superior to the old one in almost every particular, is nearing completion. The cost of this barn, fully equipped, together with the expense of grading and of providing temporary shelter for the cattle and horses, will absorb all of that part of the insurance money available for construction purposes. The other buildings necessary for the purposes of the Station are a combination carriage house and horse barn, a storage building for machinery and grain and new poultry houses, all of which must be built, if built at all, by the use of funds specially provided by the Legislature. The probable cost of the proposed structures, based upon estimates by the State Architect for the principal ones, is stated later.

Fire protection.—A main of the water system of the city of Geneva reaches the Station but supplies no pressure for fire pro-

tection purposes. The city fire apparatus is located one and one-half miles or over from the Station buildings, with a constantly rising grade from the city to the Station. At least thirty minutes must elapse before the city department can give aid. The Experiment Station unquestionably must provide its own fire protection. A plan has been adopted for doing this, the estimated cost of which is given below. That such protection is essential and wise, in view of the work the Station is doing and the value of the equipment subject to destruction by fire, is self-evident.

Electric lighting, motor service, etc.— The time has come when the Station needs for various purposes, including lighting, motor service and chemical operations, the modern conveniences derived from a supply of electricity.

The nearest wires of the Geneva Light and Power Company are about a mile distant, and considering the local cost of a current and the abundant steam power already in operation at the Station, it seems wise for the Station to install its own plant.

Poultry plant.—As two poultry houses were burned in the late fire, additions must be made to the existing houses.

Fences.— The Station property is bounded on three sides by city streets. At least 400 rods of old fencing must be replaced at once by new, which should be attractive in appearance and a discouragement to marauders.

THE SPECIAL APPROPRIATION DESIRED.

In view of the real needs herein set forth, I recommend to your Board of Control that you ask the Legislature of 1903 for a special appropriation of $25,000 to provide for the following expenditures:

Construction horse barn and carriage house........	$8,500 00
Storage building for grain and machinery.........	4,500 00
Extension of poultry plant......................	700 00
Four hundred rods of fence......................	600 00
General repairs	700 00
Fire protection, including pump, chemical engine, hose, hose cart, and 1,000 ft. pipe...............	5,000 00

Electric plant, including dynamo, storage battery, motors, cable and wiring	$5,000 00
Total	$25,000 00

MAINTENANCE FUNDS.

It is recommended that the Legislature be requested to make the following appropriations for maintenance for the fiscal year succeeding October 1, 1903, an increase of $3,000 over former years being necessary to pay sufficient salaries and meet the rise in the cost of labor:

Maintenance fund:		
Salaries	$24,000 00	
Labor	13,000 00	
General expenses	16,000 00	
		$53,000 00
Horticultural investigations		8,000 00
Fertilizer inspection		10,000 00
Feeding stuffs inspection		2,500 00

THE MAILING LIST.

The number of residents of New York to whom our bulletins are sent continues to show a steady increase, our list showing 1,181 more names than were recorded a year ago. The total increase for the popular bulletin list is 1,362. Since January 1, 1896, the mailing list for New York has increased about 18,000 names, or approximately 3,000 names per year. This represents a normal and not a forced growth.

BULLETIN LISTS, JANUARY 1, 1903.

Popular Bulletins.

Residents of New York	35,281
Residents of other States	1,300
Newspapers	770
Experiment stations and their staffs	813
Miscellaneous	131
Total	38,295

Complete Bulletins.

Experiment stations and their staffs	813
Libraries, scientists, etc	265
Foreign lists	210
Individuals	1,550
Miscellaneous	131
Total	2,969

WORK IN SECOND JUDICIAL DEPARTMENT.

The lines of work now in progress in the Second Judicial Department are as follows:

(1) Potato spraying experiments.
(2) Asparagus spraying experiments.
(3) Investigation on the rots of cabbage and cauliflower.
(4) Cane blight and other raspberry diseases.
(5) Spraying for control of San José scale.
(6) The growing of chestnuts.
(7) The commercial value of orchards of dwarfed apple trees.
(8) A study of grape stocks.

As results are reached in these various directions they will be published.

Much of the other work done by the Station is as useful to the people of the region contiguous to New York city as to the farmers of those sections where the experiments are conducted.

Mr. F. A. Sirrine, the special agent of the Station, is now located near Riverhead.

INSPECTION WORK.

This includes the same lines of inspection that are enumerated in my report for 1901.

An outline of what has been accomplished in 1902 is as follows:

Inspection of fertilizers.— For 1902 71 manufacturers licensed 548 brands of fertilizers. The Station's collecting agents visited 199 towns between April 2 and July 31, obtaining 924 samples of fertilizers, representing 446 brands.

The following tabulated statement shows the average composition of the complete fertilizers collected during the year, together with a comparison of the guaranteed composition and that found by analysis.

AVERAGE COMPOSITION OF COMPLETE FERTILIZERS COLLECTED.

	Per cent. Guaranteed.			Per cent. Found.			Average per ct. found above guarantee.
	Lowest.	Highest.	Average.	Lowest.	Highest.	Average.	
Nitrogen	0.41	8.23	**1.92**	0.68	8.97	**2.24**	**0.32**
Available phosphoric acid	1.50	12.00	**7.71**	1.72	12.00	**8.62**	**0.91**
Insoluble phosphoric acid	......	......	......	0.01	5.84	**2.14**	....
Potash	1.00	11.00	**4.45**	0.55	13.33	**4.67**	**0.22**
Water-soluble nitrogen	......	......	......	0.00	5.72	**0.93**	....
Water-soluble phosphoric acid	......	......	......	0.00	9.80	**5.46**	....

COMMERCIAL VALUATION AND SELLING PRICE OF COMPLETE FERTILIZERS.

Commercial Valuation of Complete Fertilizers.	Selling Price of One Ton of Complete Fertilizer.			Average increased cost of mixed materials over unmixed materials for one ton.
Average.	Lowest.	Highest.	Average.	
$20 76	$16	$44	$26 14	$5 38

In the table below we present figures showing the average cost to the purchaser of one pound of plant-food in different forms in mixed fertilizers.

AVERAGE COST OF ONE POUND OF PLANT-FOOD TO CONSUMERS IN MIXED FERTILIZERS.

Nitrogen	20.8 cents.
Phosphoric acid (available)	6.1 cents.
Potash	5.7 cents.

Inspection of commercial feeding stuffs.— Bulletin 217 shows that for 1902 eighty-five manufacturers or jobbers paid a license fee on 129 brands of feeding stuffs.

The list of licensed brands may be classified as follows:

	Brands
Cottonseed meal	3
Linseed meal	8
Gluten meal	4
Gluten feed	7
Germ oil meal	1
Distillery grains	5
Brewer's grains	2
Malt sprouts	4
Hominy feed	16
Corn bran	2
Meat and bone meal	15
Proprietary or mixed feeds	62
Total	129

Late in 1901 and early in 1902 the Station's collecting agents took 143 samples of feeding stuffs, which were analyzed and reported in Bulletin 217.

CLASSIFICATION OF SAMPLES ANALYZED.

	Samples.	Brands.	Samples unlicensed goods.
	No.	*No.*	*No.*
Cottonseed meal	9	7	5
Linseed meal	11	6	1
Gluten meal	2	2	....
Gluten feed	6	5	2
Germ oil meal	1	1	....
Distillery grains	1	1	....
Malt sprouts	8	8	6
Hominy feed	13	19	4
Mixed offals (bran and middlings)	17	5	....
Ground grains	6	5	....
Meat and bone meal	5	5	....
Proprietary or mixed feeds	64	54	16
Total	143	118	34

It is gratifying to note that the discrepancies between the guarantees and the actual composition of the samples as analyzed are becoming less numerous from year to year. This may readily be seen from the following list:

SAMPLES FALLING BELOW GUARANTEES.

	In protein.	In fat.
	Per ct.	*Per ct.*
1900	50	30
1901	31	23
1902	11	21

A large number of samples taken late in 1902 are now in hand awaiting analysis.

The results of this inspection show that while the brands of feeding stuffs as a rule compare favorably with the guarantees filed at the Station, the character of the goods is such, in many cases, as to demand on the part of the purchasers watchfulness and close scrutiny of the materials offered in our markets. Oat hulls and other nearly worthless stuff are still freely used as adulterants and while the manufacturers exercise care that the guaranteed percentages of protein and fat shall be maintained, the carbo-hydrate compounds of many brands are of a very inferior character.

Inspection of insecticides.— During the past year 44 samples of paris green and two of other materials have been taken, representing 23 manufacturers. Our results indicate a satisfactory condition as to the arsenic content of paris green found in the market during 1902, and the same can be said as to the amount of water-soluble compounds present in the samples examined.

Inspection of Babcock test glassware.— The Station has continued to test and mark as required by law all Babcock glassware received for that purpose. The responsibility for having this done rests with the creameries and cheese factories. It is unquestionably true that the effect of this inspection has been very beneficial.

DEPARTMENT OF BACTERIOLOGY.

Rusty spot in cheddar cheese.— The fact that this trouble is due to the presence of a specific bacterium was pointed out in Bulletin No. 183. In connection with the Dairy Department the Department of Bacteriology has worked out and tested a plan of exposing all the factory utensils to live steam for 20 minutes on each of three days per week. Where this plan has been carefully followed the trouble has been held below the limit where it would cause financial loss. In some factories the germs causing the trouble continue to be brought by the patrons after the factory is put in a satisfactory condition. This phase of the subject is now under consideration.

Cheese curing.—Work in connection with the Chemical and Dairy Departments on the causes of cheese ripening continues to occupy much time. During the year a definite advance has been made in measuring the different factors concerned in the breaking down of the casein. The important part taken by acid-forming bacteria in the process of manufacture and in certain later changes as well as the action of the pepsin of the rennet in the decomposition of the casein have been worked out in detail.

Gas formation in canned peas.— The commercial canning of fruit and vegetables is an industry important to the agriculture of this State, but thus far its problems have received little attention. During the year assistance has been rendered in extricating a factory from serious trouble with gas formation in canned peas, and the results of our work upon this subject will soon appear as a bulletin.

DEPARTMENT OF BOTANY.

Potato spraying experiments.—Very few farmers in New York spray potatoes regularly. Because blight and rot are not destructive every season, many persons doubt that it pays to spray regularly. In order to obtain some definite information on this point the Station has undertaken some experiments designed to determine how much the yield of potatoes in New York may be increased, *on the average,* by spraying. A second object of the experiments is to compare the benefit from three sprayings with that from spraying every two weeks.

The experiments are to be conducted during ten consecutive years in order to secure reliable averages. One experiment is located on the Station farm at Geneva; the other near Riverhead, Long Island. The results for the first year are as follows: At Geneva, where late blight was severe and the tubers rotted some, three sprayings increased the yield by 98½ bushels per acre, and seven sprayings increased it 123½ bushels per acre. At Riverhead, where there was neither blight nor rot, three sprayings increased the yield 27 2-3 bushels per acre, and seven sprayings increased it 45 bushels per acre.

Wrinkling of apple and quince leaves.— In June apple and quince foliage over the greater part of the State became much wrinkled, blistered and distorted. An investigation showed that the trouble was caused by severe late frosts which occurred on May 10th and 11th while the leaves were partially unfolded. Ice crystals formed between the lower epidermis and the green tissue of the leaf causing a separation. Thereafter the epidermis ceased to grow and expand, and being unable to spread out laterally took the form of an arch and thus brought about large interior cavities or blisters. Some of the blisters broke, others did not. The wrinkling seemed to interfere but little with the action of the leaves and it is doubtful if any appreciable damage was done.

Spray injury to apple foliage.—In July apple foliage in western New York became yellow and spotted and many leaves fell prematurely. Unquestionably this was chiefly due to spraying. The protracted cold wet weather made apple foliage unusually tender and susceptible to spray injury. In midsummer it seemed as if the orchards must be much injured, but at the close of the season sprayed orchards had the advantage in spite of the injury to the foliage. Scab was unusually destructive in unsprayed orchards. The spraying of apples should not be discontinued.

Raspberry cane blight.— It has now been conclusively proven by inoculation experiments that the fungus, *Coniothyrium* sp., so universally found on raspberry canes dying with cane blight is the cause of the disease. Infection occurs on the new canes in summer and autumn and, probably, also on the fruiting canes in early spring. The bluish-black areas which appear on the new

canes in autumn and which were formerly mistaken for the early stage of cane blight certainly have no connection with the disease, but, instead, they seem to be due to a comparatively harmless fungus, *Sphaerella rubina.*

Spraying experiments with cane blight are in progress. Thus far it has not been ascertained what can be accomplished by spraying the new canes, but the experiments show that it is useless to spray the fruiting canes with bordeaux mixture.

In a plantation of Cuthbert damaged about 25 per ct. by cane blight, rows sprayed three times in the spring gave an average yield of 185¼ pints while the average yield of unsprayed rows was 203½ pints.

The new apple rot.— In the autumn of 1902 there was a remarkable epidemic of apple rot in New York State caused by a common fungus, *Cephalothecium roseum,* which has been known to scientists for over sixty years and during all that time supposed to be harmless. Inoculation experiments show that the fungus is unable to penetrate the uninjured skin of apples, but that when the skin is once broken by other agencies it is capable of causing rot. In the present case it took advantage of breaks in the skin made by scab.

Since only scabby apples were attacked by the rot the trouble might have been prevented by thorough spraying to prevent scab. In cold storage the fungus, although not killed, does no damage. Unsuccessful attempts have been made to prevent the decay of slightly affected apples by dipping them in solutions of copper sulphate and formalin of various strengths. Briefly stated, the proper treatment for this new apple rot is, to spray thoroughly and place in cold storage as soon as gathered.

DEPARTMENT OF ENTOMOLOGY.

The investigations upon the origin and early stages of sexual and parthenogenetic eggs of aphids are being continued. A series of observations upon the fly-resisting qualities of about 30 varieties of wheat planned for the past season were carried out only in part owing to the scarcity of the Hessian fly.

The San José scale — Further studies in methods of control.— Experiments with the lime-sulphur-salt wash as a remedy for the

scale have been conducted simultaneously in four sections of the State, namely, on Long Island near Riverhead, in the upper Hudson Valley near Kinderhook, in western New York at Geneva and near the extreme western part of the State in Niagara County. The treated trees numbered 713, of which 251 are peaches, including 11 varieties; 129 plums, Japan varieties; 248 pears, including about 6 varieties; 3 sour cherries and 31 large Baldwin apple trees.

The trees were examined frequently during the summer to ascertain results. The effect upon the trees and scales was practically uniform in all the orchards. There was no evidence of injury except on Long Island where the fruit-buds of the Japan plums were apparently slightly injured, due in all probability to the late date of treatment. In all cases the foliage was delayed about a week but was uniformly as good or better than that of the check trees. All of the treated trees, with the exception of the Japan plums, bore a fair crop of fruit practically free from scale. In some cases, especially the apples, the crop was greatly increased. The fruit on the check trees was in every case badly disfigured and unmarketable.

The effect upon the scale was equally pronounced. The check trees in all the orchards showed an abundance of living scale on both the old and the new growth while on the treated trees only an occasional scale was found.

The wash adhered to the trees much better than was anticipated. All of them remained white for at least two months and a residue remained adhering to the bark throughout the season.

The lime-sulphur-salt wash combines readily with bordeaux mixture. A number of experiments were made with this compound which gave highly satisfactory results.

DEPARTMENT OF HORTICULTURE.

Variety tests.— The former custom of issuing annual bulletins containing observations on varieties of small fruits was discontinued in 1899. The first report on strawberry varieties published by the Station since then is contained in Bulletin No. 218, November, 1902. In that bulletin are given careful descriptions of the new varieties of strawberries which have been fruited at the

Station, together with lists of the kinds most productive here, of new kinds apparently worthy of testing, of medium early varieties, of late varieties and of varieties having a long fruiting season. Other characteristics of interest to strawberry growers are also set forth.

Pollen studies.— In a laboratory study of grape pollen in 1902 the interesting discovery was made that the self-sterile varieties of the grape which were studied have a pollen of a peculiar form which, when examined dry under the microscope, may readily be distinguished from the pollen of self-fertile grapes. This discovery appears to disclose a quick and reliable way for answering the question whether or not a variety is self-sterile. The microscopic examination of the pollen is a much easier and more expeditious method for answering this question than the old way of bagging the clusters before the blossoms open to prevent the access of other pollen and in due time observing whether any fruit is formed under such conditions. An account of this work is published in Bulletin No. 224.

Self-fertility of grapes.— From 1900 to 1902 certain other questions pertaining to the self-fertility of the grape were investigated which were treated in Bulletin No. 223. In previous tests varieties which are self-sterile, or nearly so, have shown about as little ability for fertilizing other self-sterile sorts as they have for fertilizing themselves. In the tests reported in Bulletin No. 223 they have usually failed to fertilize self-fertile sorts also. In some instances, however, indications were found that some self-impotent pollen was potent to some extent on other varieties.

The influence on self-fertility of girdling or sharply bending the fruiting canes before the blooming season was also investigated. In some cases self-fertility or imperfectly self-fertile sorts were stimulated to increased productiveness by such treatment. In other cases they were not. Further tests need to be made to learn whether or not this practice may be profitable with any of our commercial varieties. The method is not new in viticulture. It is practiced by Greeks with Zante grapes to promote setting of fruit and to secure uniformity of bunch and increased size of berry. The ring of bark which is taken out is so narrow that the

wound readily heals over. In this respect the method differs from that used in girdling grapes after the fruit sets as described in Bulletin No. 151.

BULLETINS PUBLISHED IN 1902.

No. 212. April.— Miscellaneous notes on injurious insects, II: (1) The periodical cicada; (2) the palmer worm; (3) white grubs attacking aster plants; (4) *Papilio asterias* attacking celery. V. H. Lowe. Pages 25.

No. 213. April.— Treatment of San José scale in orchards, II: Spraying with kerosene and crude petroleum. F. A. Sirrine. Pages 25.

No. 214. July.—A study of some of the salts formed by casein and paracasein with acids: Their relation to American cheddar cheese. L. L. Van Slyke and E. B. Hart. Pages 27.

No. 215. September.— Methods for the estimation of the proteolytic compounds contained in cheese and milk. L. L. Van Slyke and E. B. Hart. Pages 22.

No. 216. September.—Analysis of commercial fertilizers for the spring and fall of 1902. L. L. Van Slyke and W. H. Andrews. Pages 65.

No. 217. November.— Inspection of feeding stuffs. W. H. Jordan, C. G. Jenter and F. D. Fuller. Pages 19.

No. 218. November.—Variety test of strawberries. O. M. Taylor. Pages 14.

No. 219. December.— Some of the compounds present in American cheddar cheese. L. L. Van Slyke and E. B. Hart. Pages 14.

No. 220. December.— Two unusual troubles of apple foliage: I. Frost blisters on apple and quince leaves; II. spotting and dropping of apple leaves caused by spraying. F. C. Stewart and H. J. Eustace. Pages 17.

No. 221. December.— Potato spraying experiments in 1902. F. C. Stewart, H. J. Eustace and F. A. Sirrine. Pages 29.

No. 222. December.— Report of analyses of paris green and other insecticides in 1902. L. L. Van Slyke and W. H. Andrews. Pages 4.

No. 223. December.— Investigations concerning the self-fertility of the grape, 1900–1902: (1) Potency of the pollen of self-sterile grapes; (2) influence on self-fertility of girdling or bending the canes. S. A. Beach. Pages 22.

No. 224. December.— Investigations concerning the self-fertility of the grape, 1900–1902, III: A study of grape pollen. N. O. Booth. Pages 12, plates 6, fig. 1.

No. 225. December.— Control of rusty spot in cheese factories. H. A. Harding, and G. A. Smith. Pages 27.

No. 226. December.— Raspberry cane blight and raspberry yellows. F. C. Stewart and H. J. Eustace. Pages 38, plates 6.

No. 227. December.—An unusual apple rot following scab. H. J. Eustace. Pages 25, plates 7.

No. 228. December.—San José scale investigations, IV: Spraying experiments with the lime-sulphur-salt wash; summer treatment with lime-sulphur washes; experiments in making a lime-sulphur wash without boiling; spraying experiments with other washes. V. H. Lowe, and P. J. Parrott. Pages 68, plates 7.

No. 229. December.— Director's report for 1902. W. H. Jordan. Pages 15.

W. H. JORDAN,
Director.

New York Agricultural Experiment Station,
Geneva, N. Y., Dec. 31, 1902.

REPORT

OF THE

Department of Bacteriology.

H. A. Harding, *Dairy Bacteriologist.*

G. A. Smith, *Dairy Expert.*

J. F. Nicholson, *Assistant Bacteriologist.*

Table of Contents.

REPORT OF THE DEPARTMENT OF BACTERIOLOGY.

CONTROL OF RUSTY SPOT IN CHEESE FACTORIES.*

H. A. Harding and G. A. Smith.

SUMMARY.

(1) Rusty spot in cheddar cheese is present in the output of a number of factories in this State.

(2) The rusty spots are caused by the growth in the cheese of a red bacterium, just as green streaks in stale bread are caused by the growth of a green mold.

(3) The trouble is most evident in moist home-trade cheese.

(4) The use of cheese color can not be relied upon to entirely disguise the red spots.

(5) Steaming the factory utensils as a means of combating this trouble has been tried in a number of infected factories during the past two seasons.

(6) The results thus far show that this treatment applied thoroughly three times per week will prevent financial loss except under very unusual conditions.

(7) While under ordinary conditions the factory seems to be the main seed bed of the germs, cheeses made from the milk of individual patrons indicate that at times the milk of some patrons contains the germs causing rusty spots.

*A reprint of Bulletin No. 225.

INTRODUCTION.

Among other subjects discussed in Bulletin No. 183 of this Station was the trouble known as "rusty spot in cheddar cheese." The trouble has continued to appear in factories in different parts of the State. During the past two seasons we have studied it in four infected factories. Our object in this study has been to develop a method of control which can be applied by the factoryman with ease and certainty. This bulletin gives the results of our work and observations in these factories, together with the methods which we have devised for the control of the trouble.

ACKNOWLEDGMENT.

For obvious reasons the names of the factories and their makers will not appear in this publication but we wish to acknowledge our indebtedness to the factorymen for their active and intelligent cooperation during the progress of this investigation. Much of the success of the investigation is due to their thoughtful observations.

GENERAL NOTES ON RUSTY SPOT.

APPEARANCE IN CHEESE.

Usually the first intimation of trouble which the factoryman has is the statement from the buyer that part of his last shipment was cut or rejected because there were spots of a reddish color on the inside of the cheese. Plugs drawn from cheese on the shelves look as though they had been lightly sprayed with red ink or cheese-color, depending upon whether the spots are bright red or yellowish red like fresh iron rust. When a cheese is cut or broken open and the surface closely examined, the color will be found scattered in points the size of a pin point and larger. While this color occurs fairly evenly throughout the cheese it is usually most noticeable on the surface of the gas holes and other openings. If there is free moisture in these places the color will be mechanically distributed over the surface of these holes and form a yellowish red blotch which may be as large as the thumb nail. These blotches can be readily seen at a distance of several feet and they are responsible for the financial loss because they

are what attracts the unfavorable attention of the consumer. In very bad cases the whole interior of the cheese will be as highly colored as though annatto had been used, except that the color will not be evenly distributed. The spots are not present in the freshly pressed cheese but they can be found when the cheese is four to eight days old. A warm curing-room hastens their growth, while a cool one retards it. During the time the cheese is usually held in the factory the spots continue to grow but if no blotches are formed in ten days there is little probability of a cut in price.

WHY THE PRICE IS CUT.

There is no evidence that the discoloration is in any way injurious to the health of the consumer, and we have repeatedly partaken freely of the worst cases with no bad effects. The texture and flavor of the cheese do not seem to be in any way affected by the presence of the spots. The cut in price comes from the fact that when the consumer notices the abnormal appearance of the cheese he thinks it must be bad and will not accept it. As a result the retailer returns the cheese to the wholesaler from whom he purchased it. This cheese is spoiled by being cut, and is sold to a lunch counter for a small price; while others of the affected lot are disposed of at a reduced price to the retailer who does not have a discriminating trade. Since the spots do not affect the flavor and are not injurious to health the factoryman will naturally feel that this treatment is unjust; but the discrimination merely illustrates well the old proposition that in order to cater to a first-class trade, the producer must consider appearance as well as quality. In considering this trouble from a commercial standpoint it should be remembered that, unless the red points are of sufficient size to be readily seen or blotches are formed in the cheese, there is little probability of a cut in price.

RUSTY SPOT NOT TABLE STAIN.

This spotted appearance of the inside of the cheese should not be confused in any way with the pink discoloration of the rind and bandage by some termed table stain. This latter trouble is often noticed, especially in damp curing rooms, and is due to the

action of mold. Table stain can be controlled by carefully washing the shelves to remove the mold, followed by burning sulphur, and attention to the ventilation.

FALSE THEORIES AS TO CAUSE OF RUSTY SPOT.

Many explanations have been advanced by different persons to account for the appearance of these rust-colored spots in cheese. From their color it was at first supposed that the spots were due to iron rust from handling the milk in old cans or rusty vats. A chemical examination showed that these rusty looking portions contained only a trace of iron, no more than is found in a normal cheese. Some buyers held that the trouble was due to adding cheese-color irregularly, but the trouble was very bad in factories where no color had been used.

Poor salt has been blamed, but the trouble is found in factories using the very best grades of salt and has come and gone while the same barrel of salt was in use.

The fact that the trouble does not appear until the cheese is some days old and that from this time it continues to increase for some days plainly indicates that it is due to the action of some form of life in the cheese.

HISTORY OF RUSTY SPOT.

OUTBREAKS IN THE STATE.

The earliest reported appearance of rusty spot in this State was in St. Lawrence County in 1883. For many of the facts connected with this outbreak we are indebted to Mr. W. W. Hall, who was a resident of this county and prominent in cheese matters at that time. In July of that year the rusty spots were noticed in the cheese at the Elmdale cheese factory near Gouverneur.

The factorymen were utterly at a loss to account for them as they were making white cheese and had used no coloring matter. The trouble did not develop to any considerable extent and about September 1 it disappeared for the remainder of that year. The following season it was much worse and continued longer.

The trouble spread until nearly all of the factories in that section were affected to such an extent that at times they resorted

to coloring the cheese in order to cover up the spots. In some cases the factory would have no trouble until the autumn months, when it would suddenly develop very rapidly, quite often becoming so marked that it was impossible to cover it with annatto. The spots were rarely discovered in the early spring months, yet there were some factories where they showed to a greater or less degree throughout the whole season.

About ten years ago this trouble developed in the factory at Hailesboro. This factory had good drainage and was well built and well managed. The trouble continued for a number of seasons and the financial loss was some hundreds of dollars. The method of manufacture was changed and a very dry, high-colored cheese made, but the trouble was unchecked and the spots showed through the cheese-color. As a last resort the making of cheese was abandoned and the cream was made into butter, although the financial returns were then less than those obtained from good cheese. The making of butter at this factory is still continued.

We have not received a report of a serious outbreak of the trouble in St. Lawrence County during the last few years.

The Miller factory at Constableville had an outbreak of the spots about 1888. Here it was so severe that coloring the cheese failed to cover the discolorations. The factory lost heavily both in patronage and in the price of its product. The trouble continued until the total destruction of the factory by fire some years later. A modern factory was built near the site of the old one and there has been no return of the spots reported.

The old Harrisburg factory in Lewis County had an outbreak of the trouble in August, 1895. Reappearing in April, 1896, it lasted throughout the season and was so bad that the blotches showed through the cheese color. There was less of it in 1897 and since that time it has not appeared. An old upright press which was discarded in the overhauling which the old Harrisburg factory received while fighting the rusty spots was taken to the adjoining Silver Springs factory. Trouble soon developed in the latter and continued until it resulted in the closing of the factory. After standing idle one season the factory was thoroughly overhauled and partially rebuilt. Since that time no trouble has been reported.

The trouble has been observed in nearly all sections of the State where white cheese is made. Cases of it have been reported to us from St. Lawrence, Jefferson, Lewis, Oneida, Oswego, Allegany and Cattaraugus counties.

PREVIOUS SCIENTIFIC WORK.

In 1896 W. T. Connell studied an outbreak of rusty spot at a Canadian factory. From the infected cheese he isolated an organism which he named *Bacillus rudensis*[1] and when a starter of this organism was added to a vat of good milk the rust-colored spots were reproduced in the cheese. He concluded that the trouble was largely due to air-borne infection from the red growth along the factory drains.

Beginning in 1899 we have repeated and extended these observations as to the cause of the discolorations in the cheese. We have studied outbreaks in a number of factories in widely separated portions of this State and in all cases we have found *Bacillus rudensis* present in large numbers in the rust-colored spots in the cheese.[2] We have many times repeated the experiment of adding a starter of this organism to a vat of good milk and have reproduced the rusty spots in the resulting cheese.

NECESSITY FOR THE PRACTICAL APPLICATION OF THE ABOVE RESULTS.

The work of Connell showed that *Bacillus rudensis* was at least one of the germs causing rusty spot in cheddar. Our own work has rendered it probable that it is the only germ directly concerned with this trouble.

Knowing only this fact we were not able to give specific advice in the practical problems which confront the dairymen in infected factories, but the fact was valuable because it gave a sound basis upon which to formulate methods of controlling the trouble.

In planning methods we have kept in mind the fact that to be of most benefit the process must be neither so costly as to discourage the factoryman nor so vague in its directions as to confuse him and cause him to spend his time in fruitless effort.

This publication is a record of our attempt to apply our knowledge to actual conditions as they are found in infected factories.

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[1]Connell, W. T. Discoloration of Cheese. Canadian Dept. of Agr., Bul., 1897.

[2]Harding, H. A., Rogers, L. A., and Smith, G. A. Notes on Some Dairy Troubles. N. Y. Agr. Exp. Sta. Bul. 183, Dec. 1900.

INVESTIGATIONS.

WORK AND RESULTS AT FACTORY NUMBER ONE.

Factory Number One is a large one in the northern part of the State and has long had an enviable reputation for turning out a fine product. The building, though an old one, is in good repair and its location, while high and dry, is on a level area not affording good natural drainage. It produces a variety of cheese, both colored and uncolored, but makes a specialty of a small-sized cheese for home trade.

The first outbreak of rusty spot occurred in the autumn of 1900 after receiving patronage from a neighboring infected factory. The trouble was not discovered until a large stock of cheese had been accumulated for the winter trade and the financial loss was correspondingly heavy. During the winter the question was put to us very forcibly: " What shall we do to stop the trouble? The financial loss is more than we can stand and our business will be ruined if the rusty spots can not be controlled."

Although every thing about the factory seemed in good order we recommended as a preliminary step the thorough cleaning of the factory and the whitewashing of the inside walls. This was done. Early in May the spots again appeared in the cheese, showing that the cleaning had not removed the trouble. We then discussed the advisability of using formalin to complete the disinfection. The work of Connell had laid stress upon the danger of contaminating the curd through the air. The advantage of formalin lay in its ability to disinfect the walls, ceilings and floor as well as the tools and thus decrease the probability of germs being carried to the curd. However the cost of the amount of formalin necessary for a single treatment of the factory was found to be oven ten dollars. Added to this was the difficulty of making the room sufficiently tight to hold the gas for the required length of time. On account of the work and expense involved as contrasted with the simplicity and effectiveness of the steaming process, later to be described, we abandoned the idea of using formalin.

On May 14, in addition to the ordinary cleaning of the tools, the curd mill was submerged in hot water for an hour. When the

cheese of the following day was examined after the necessary interval no spots were found. The occasional boiling of the mill was continued, but the spots in the cheese again became plentiful. The red points were abundant in all the cheese made between June 25 and July 3. In the cheese of the latter day the points were very closely set, and could be readily seen by the ordinary observer.

After the cheese was in press on July 3 the curd mill, knives, rakes, conductors and everything which came in contact with the milk were put into the vat, covered with water and heated with steam. It took two hours to heat this water to 160° F. and consumed a large amount of steam. The process had the further disadvantage that the hot water tended to warp the wooden utensils. The weigh can and remaining vats were heated with direct steam.

This heating was repeated on July 12, except that the water was left out of the vat and the utensils were heated with direct steam. In doing this a heavy cloth cover was drawn over the vat to retain the steam, and the temperature was raised to 180° F. and held there 15 minutes, so that the heat would penetrate all portions of the tools. The consumption of steam, while considerable, was far less than when the water was used and the heating of a vat full of tools could be completed in 20 minutes.

The effect of this treatment upon the cheese was prompt and satisfactory. The cheese made July 4 contained less than $\frac{1}{100}$ as many red points as that made the preceding day and these red points remained small and hard to find at the end of 12 days.

While the activity of the germs was checked by this heating, they were not all removed, and in the succeeding days the spots appeared in varying numbers, but it was only in the cheese of July 12 that they were recorded as large enough to be easily seen. As it chanced, the second steaming occurred immediately after this cheese was made; and ten days later only a few points could be found in the cheese made July 13.

In connection with our work we made a number of trips to the factory to observe the treatment in operation, to compare ideas with the factorymen and to examine the cheese upon the shelves.

These latter observations were supplemented by others made upon samples taken by the factorymen from the cheese of each date just as the latter was ready for shipment and mailed direct to us. In one or both of these ways we were able personally to pass upon the product of each day from June 27 to August 17, beside making occasional observations before and since that time.

While the cheese of this factory was of the home trade type, it was so carefully made during this season that little free moisture was present, and as a result the formation of blotches was reduced to a minimum.

Although the trouble was successfully checked, the factoryman was naturally desirous of having it entirely removed from the factory. As has been mentioned, there had been a transfer of patronage from a neighboring infected factory in the season of 1900, and it was natural to suppose that the patrons had brought the germs with them. The most probable source from which they could have obtained these germs was through the whey from this factory.

Since in this way the whey had been brought under suspicion as being a means of spreading the trouble the factoryman was desirous of pasteurizing his whey and thus cutting off the transfer to his patrons of germs to be later returned with the milk.

To accomplish this a ¾-in. steam pipe was connected with the whey vat and about 10 ft. of the pipe placed around the bottom. The vat received the whey from about 10,000 lbs. of milk. The following observations were made on the first heating, July 24. Heating began at 11.00 a. m. when the whey showed a temperature of 95° F.; by 11.20 this had risen to 140° and by 12.05 to 162°. Steam was then turned off and the whey cooled slowly, the temperature at 2.15 being 158°, at 3.30 140°, and at 7.00 a. m. the next day 110°. This high temperature in the morning was probably due to a slight inflow of steam through valve leakage.

The heating to 162° F. was repeated on July 25, 26 and 27, but was temporarily discontinued on account of the leaking of the vat. As a result of the heating there was a slight settling out of the solids, but any difficulty in a fair division of the whey could be readily overcome by an occasional stirring. On the following

morning the whey was still sweet to taste, indicating that fermentation had been checked and that the whey was in prime condition for feeding.

The heating of the factory utensils was repeated on July 24 and 27, and August 3 and 9. Examination of cheese made during this period showed that after July 24 the spots decreased in number so that during a considerable portion of the time few or none could be found.

After the beginning of the treatment in July there was very little of the cheese where the spots would be detected by any but an experienced eye and there was no financial loss on this account. Since the close of our regular observations no outbreak has occurred, and occassional examinations of the product of this factory have failed to show any red points.

At the beginning of the trouble we had recommended that all the cheese be colored to guard against loss. This was done until after the heating had shown itself to be effective, when a part of the cheese was regularly made uncolored during the remainder of the season.

EXPERIENCE IN A BRANCH OF FACTORY NUMBER ONE.

During the season of 1901 a slight outbreak of rusty spot occurred at a branch of this factory. Steaming of the vats and utensils, according to the same plan which had been followed at the main factory, was immediately begun, with the result that the spots disappeared in a short time and have not since reappeared.

WORK AND RESULTS IN FACTORY NUMBER TWO.

In Factory Number Two, which was widely separated from Factory Number One, there was an outbreak of rusty spot in the autumn of 1900, causing a considerable financial loss. This fact was reported to us in November, too late to do anything with it at that time. The trouble again became so marked as to attract attention in July, 1901. We visited the factory on July 31 and found red points in stored cheese of the preceding May.

The factory is a wooden building in good repair situated in a valley near a small creek which affords opportunity for good drainage, but this has not been utilized to the fullest extent. The

whey vat was in fair condition and located about 30 ft. from the factory and at the side of the creek. The inside of the factory was not ceiled but side walls had been whitewashed during the season. The product was a moist, loose-textured home-trade cheese, very favorable for the development of red spots or blotches.

An examination at the factory on July 31 showed that distinct blotches had been formed in the cheese of July 17, 20, 23, 25 and 26, and red points were evident in cheese of July 27 and 28. A later examination of samples on August 9 and 13 showed blotches in cheese of July 27, 28, 30 and 31.

Owing to his desire to sell the greatest possible amount of water at cheese prices the maker wished to continue, if possible, the manufacture of this very soft cheese. As a precaution we recommended coloring the cheese, which was begun August 2, and has been continued to the present time.

On July 31 all of the utensils which came in contact with the milk were placed in the vats and steamed at 180° F. for 15 minutes.

A curd sink was in use at this factory and this was treated in the same way as the vats except that from its more open construction the work could not be as satisfactorily carried out. The weigh can was inverted and the steam introduced through the faucet. This heating was repeated on August 1, 2, 3, 5, 6, 7, 8, 9, 10, 12, 15 and 17. A steam connection was made with the whey vat and the whey was heated to 145° on August 2, 3, 5, 6, and each succeeding alternate day until the 17th. At this time the heating was discontinued because the vat was leaking.

During the first four days after the beginning of the heating the milk was handled in two vats and there was a marked difference in the number of red points present in samples of the cheese from the two vats on each day. After this time the milk was made up in a single vat and no further observations of this kind were possible.

On August 1 and 2 the cheese from one vat was blotched but the use of cheese-color prevented the blotches from showing in the cheese of August 2. The cheese of August 3 showed only an occasional red point and after this date the points, though

present, were not sufficiently numerous to cause trouble until August 15. On this date blotches were formed, though fortunately they were obscured by the cheese-color. It so chanced that the steaming of the utensils occurred on this day and not a single red point could be found in the sample from the cheese of August 16. The small red points in the colored cheese were so difficult to detect with the unaided eye that the maker overlooked them and thought that the trouble had disappeared. Accordingly he restricted the heating to the utensils placed in the curd sink on August 19, 21 and 31, and then entirely ceased the steaming. Left to itself the trouble increased again until the cheese-color failed to cover up the blotches on August 28, September 1, 3, 6, 7, 9, 10 and 11. The factory was visited on September 10 and the actual condition brought to the attention of the maker. After this date the vat and utensils were steamed regularly three times per week. The number of spots decreased rapidly, and during the first half of October entirely disappeared for over two weeks.

The principal results of this season's experience at this factory may be summarized as follows:

(1) In making moist, home-trade cheese, coloring alone can not be relied upon to cover up rusty spot.

(2) The marked difference in the development of the spots in cheese made upon the same day in different vats can best be explained by assuming an introduction of germs with the milk.

(3) In all but exceptional circumstances careful steaming, three times per week, will keep the trouble below the point where it will cause financial loss.

While the spots were kept below the point where they would cause financial loss upon the cheese, their almost constant presence indicated that there was a seed bed which our present methods did not reach. The work of 1902 was mainly directed toward determining the source of supply.

WORK AND RESULTS AT FACTORY NUMBER TWO IN 1902.

Although we kept in touch with the factory from the opening of the season, it was not until July 24 that we received samples showing the red points.

On July 31 we collected quart samples from the milk of each of the 31 patrons, and from each sample we made a little cheese,

taking care to reduce, as far as possible, the chances of contamination from the factory. The details of this method of making cheese from milk samples are given on page 47.

The little cheeses were at once brought to the Experiment Station and cured at 70° F. When examined on August 15 red points in abundance were found in the cheeses representing 5 patrons and a single red point in each of 3 others. Cultures from a number of these red points showed that they were really due to the presence of *Bacillus rudensis*. The remaining 25 samples failed to show any red points. Owing to a misunderstanding we failed to receive samples of the factory cheese made on this date.

Samples were collected from all of the patrons and little cheeses were made August 19 and 20 with the same precautions as before. When examined, August 30, one cheese of August 19 and two of August 20 contained a very few red points. These three samples represented three patrons, but two of them were among the eight whose samples had produced red points July 31.

The steaming of the factory utensils, which had been followed the preceding season, was begun in July at the first appearance of spots in the cheese. When duplicate samples from the factory cheese of August 19 and 20 were examined no red spots could be found.

As the result of these observations, and particularly of the examination of July 31, the presence of an outside source of contamination was made fairly certain, and strong suspicion was attached to the patrons as being the source of the trouble.

No further outbreak occurred this season, and consequently we were unable to carry further our investigation of this point at this factory.

The results of the treatment during the two seasons is summed up by the maker in a letter of recent date as follows: "I have had very little trouble this season. Some showed in the cheese of September 23 to 28, but I could not find a trace of it in the October cheese. I notice that if my cheese is very soft and wet the spots are more likely to appear. I find the steaming process very satisfactory, for in this way I can keep the trouble down so that it is not noticed by the buyers."

WORK AND RESULTS AT FACTORY NUMBER THREE.

The patrons of Factory Number Three suffered from rusty spot in an old factory for a number of years without finding anything which removed the trouble. The cheese was colored very high, which partly concealed the spots, but the financial loss was heavy.

As the owner was unwilling to renovate the old factory, the farmers put up a new one in the fall of 1901. This may fairly be considered a model of its kind, well built, the inside walls ceiled throughout, a cement floor in the making room and everything so constructed as to be easily kept clean. The utensils were new, except a steel gang-press which was brought with them from the old factory after having been used there about a year.

The new factory opened in March, making a white, home-trade cheese, but the presence of red spots was soon discovered. At their request we visited the factory April 10 and found a well-made lot of cheese, very generally affected with the rusty spot and blotched in most cases. They had returned to the use of cheese-color just before our visit and we instituted the same method of steaming vats and utensils which had been practiced at the other factories, with the added feature that an old creamery tank was fitted up for steaming the hoops and followers. This steaming was repeated three times per week during a considerable portion of the season.

The factory was visited a number of times, and samples were received regularly until the middle of May and at irregular intervals from that date until the close of the season. While the red spots did not permanently disappear from the cheese, they were so small and so infrequent as not to cause financial loss.

The attempt was made on April 10, 11 and 21, July 25 and August 13 to determine the presence of *Bacillus rudensis* by making a small cheese from a sample of the milk of each patron, as described on page 47. The first three of these attempts were failures, due to our lack of experience in the making of this kind of cheese, while at the two later dates there was an almost entire absence of the germ, as shown by the factory cheese.

As the result of these examinations the red spots developed in two samples from each of two patrons and in one sample

from each of two others, but the numbers present were too small to make it advisable to push the inquiry farther.

OBSERVATIONS AT FACTORY NUMBER FOUR IN 1900.

Although Factory Number Four was, in point of time, one of the first with which we worked, the discussion of our observations has been reserved because of their greater number and interest.

The first outbreak occurred early in October, 1900, but we were not called to the factory until late in the following month just as the factory was closing for the season.

The building was an old one and had apparently received few repairs. The wooden floor of the making room was broken through in a number of places, allowing the floor slops to flow through upon the stones below, which were covered with the accumulated filth of years. The whey vat had not been cleaned in weeks because it was so old that on being emptied and dried a little it would no longer hold whey. As it was, the leakage from this source maintained a large mud hole. The drainage, which was by nature fair, had been neglected. The curing room and utensils were clean and in good order, and the maker was evidently doing his best under very adverse circumstances.

Little could be done aside from explaining the cause of the trouble and urging the necessity of a thorough cleaning up and preparation for the outbreak, which was almost certain to come the following season.

WORK AND RESULTS AT FACTORY NUMBER FOUR IN 1901.

July 17 we received word that an outbreak of rusty spot had occurred and we reached the factory the following day. A striking change in the factory and its surroundings was evident. The drainage had been improved, a new whey vat and connections had replaced the old, the inside of the making room had been ceiled up, and, best of all, a cement floor had replaced the old wooden one and buried the filth beneath it.

With the opening of the season, the factory had begun the manufacture of an extremely moist, uncolored, home-trade cheese of good quality, for which trade conections at good prices were quickly established. The resulting high dividends caused the return of the patronage which had left as the result of the finan-

cial loss the preceding season, and at this time cheese was being made in three vats.

The results of our examination of the cheese on hand July 20 can best be condensed into a table.

OBSERVATIONS OF CHEESE AT FACTORY NO. 4, ON JULY 20, 1901.

Date made.	Vat.	Appearance of cheese.
July 6	West	No spots.
6	Middle	Few red points.
6	East	No spots.
7	West	Very bad—large yellowish red blotches in holes near the rind.
7	Middle	Much less than in west vat.
7	East	Very little showing.
8	West	Little except near outside of cheese.
8	Middle	Very little.
8	East	Very badly blotched.
9	West	Very bad.
9	Middle	Points fairly plenty.
9	East	Little more than in middle vat.
10	West	Fairly plenty.
10	Middle	Little more.
10	East	Least.
11	West	Plenty.
11	Middle	Plenty — shows small pieces of red curd.
11	East	Presence of points doubtful.
12	West	As little as any since July 6.
12	Middle	Little more than west vat.
12	East	About same as middle vat.
13	West	Few points; 3 or 4 on cross section of plug.
13	Middle	None found.
13	East	About same as west vat, very little.
14	West	Blotched, especially near rind.
14	Middle	Points plenty, more numerous near rind.
14	East	Points plenty, more numerous near rind.
15	....	No spots showing in cheese.

From the above notes it will be observed that the trouble appeared as an outbreak or wave which reached its crest about July 9, after which it tended to die down of its own accord. This phenomenon has been since observed on a number of occasions, but no satisfactory explanation has yet been found.

It will further be observed that there is often a marked difference in the amount of discoloration produced in the cheese from different vats on any given day.

We have already commented upon similar observations in connection with our work at Factory Number Two, and in this factory, with its larger number of vats, we have observed repeated examples of this relation during the two past seasons. During both seasons the trouble was usually most marked in the west vat, which received the milk of the first patrons.

On July 15 the factorymen had made up separately a portion of the milk from each of 30 patrons. There was the theoretical objection that in making up these samples in open vats and with a single set of tools a mixing of the germ content of the various samples would take place; and there was also considerable opportunity for contamination by germs from the factory air.

When these samples were examined July 20 six of the thirty showed a small number of red points.

Owing to the above objections to the method of manufacture and to the small number of spots found in any case, little stress was laid upon these results, but when it was found that the factory cheese, made the same day, showed only an occasional spot in the product of one vat and none in the cheese from the other vats these observations added something to the probability of an outside source of contamination.

The same method of heating the vats and utensils which was then giving satisfaction at Factory Number One was started at Factory Number Four on July 19.

The high percentage of moisture in the cheese which the factory was making gave very favorable conditions for the formation of blotches, but owing to trade relations it was desirable to continue the manufacture if possible. The presence of these blotches had led the maker to use cheese-color in an ineffectual attempt to cover up the discolorations and we advised continuing its use. However, the disappearance of the spots was so marked that after August 1 white cheese was made throughout the season, with the exception of a short time, about October 1. We have condensed into the following table the results of our observations of the cheese during the entire season.

OBSERVATIONS ON CHEESE AT FACTORY NO. 4, 1901.

Date of observation.	Date made.	Heated in P. M.	Vat.	Condition of cheese.
July 26	July 14	—	W M E	All faintly blotched.
	15	—	W M E	Only occasional spot. No spots found. No spots found.
	16	—	W M E	50 small pts. in plug. 5-6 small pts. in plug. 50 small pts. in plug.
	17	—	W M E	5-6 small pts. in plug. 2 small pts. in plug. Faintly blotched.
	18	—	W M E	Faintly blotched. Faintly blotched. 3 small pts. found.
	19	+	W M E	No spots found. 4 small pts. found. No spots found.
Aug. 6	20	+	W M E	No spots found.
	21	—	W M E	No spots found.
13	23	+	W M E	No spots found.
	24	—	...	No spots found.
	25	+	W M E	No spots found. Many small pts. No spots found.
	26	—	W M E	Many small red pts. Few scattering pts. No spots found.
8	27	+	?	Few small pts.
	28	—	W M E	Less than other two. Found plenty pts., small. Found plenty pts., small.
	29	—	?	Pts. plenty — almost enough to blotch.
	30	+	?	Many small pts.
17	Aug. 1	+	W M E	Only 1 pt. found in plug. Only 4 pts. found in plug. Only 3 pts. found in plug.
	2	—	W M E	Badly blotched. 4 pts. found in plug. No pts. found in plug.

Date of observation.	Date made.	Heated in P. M.	Vat.	Condition of cheese.
Aug.	Aug. 3	+	W M E	1 pt. found in plug. 1 pt. found in plug. No pts. found in plug.
	4	—	W M E	No spots found.
	5	—	W M E	No spots found.
	6	+	W M E	No pts. found. Few very fine pts. No pts. found.
21	7	—	W M E	No pts. found. No pts. found. Few fine pts.
	8	+	W M E	No pts. found.
	9	—	W M E	Few fine pts. No pts. found.
21	10	+	W M E	No pts. found. No pts. found. Very many small pts.
	11	—	W M E	No pts. found.
	12	—	W M E	No pts. found.
	13	+	W M E	No pts. found.
	14	—	W M E	No pts. found.
31	15	+	M E	Small pts. fairly abundant. No pts. found.
	16	—	M E	No pts. found. 4 pts. in plug.
	17	+	M E	Few pts. 2 pts. found.
	18	—	M E	No pts. Few pts.
	19	—	M E	No pts. found.
Sept. 10	20	+	M E	No pts. found.
	21	—	M E	No pts. found. Single pt. found.

OBSERVATIONS ON CHEESE AT FACTORY NO. 4, 1901 — *Continued.*

Date of observation.	Date made.	Heated in P. M.	Vat.	Condition of cheese.
Sept.	Aug. 22	+	M E	No pts. found. Faint film on holes.
	23	—	M E	No pts. found.
	24	+	M E	No pts. found. Slightly blotched.
	25	—	M E	No pts. found.
17	26	—	M E	No pts. found. Few well developed points.
	27	+	M E	Few scattering pts. Faint film on many holes.
	28	—	M E	No pts. found.
	29?	+	M E	Many small pts. No pts.
Oct. 2	Sept. 8	—	M E	No pts.
	9	—	M E	No pts.
	10	+	M E	No pts. Few pts.
	11	—	M E	No pts. found.
	12	+	...	No pts. found.
	13	—	M E	No pts. found. Few pts.
	14	+	M E	No pts. Few pts.
9	15	—	...	No pts.
Oct.	Sept. 16	—	M E	No pts. Fine points fairly abundant.
	17	+	M E	No pts. Few pts.
	18	—	...	No pts.
	19	+	...	No pts.
	20	—	...	No pts.
	21	+	...	No pts.
15	22	—	M E	No pts. 1 pt.
	23	—	...	No pts.
	24	+	...	
	25	—	M E	Fairly plenty. No pts.
	26	+	M E	Shows plainly.
	27	—	M E	Badly blotched.
24	Oct. 8	—	M E	Blotched. Many fine pts.
	9	+	M E	2 pts Many fine pts.
	10	—	M E	Few scattering pts.
	11	—	M E	Few small pts. No pts.
	12–18	....	...	No pts. from either v't.

The collection of such data over so long a period from a factory located a hundred miles from the Experiment Station would have been impossible without the hearty co-operation of the factorymen. As far as possible we have given the results of our own observations at the factory and have supplemented these with the results from samples sent us by the factorymen. The cheese made each day was dated as it came from the press, and practically the only opportunity for error in sampling lay in the chances of mixing the product of different vats. This might

occur through the distribution of the residue after filling the last hoop in any vat or through a confusion in placing the cheese upon the shelves. Constant care was exercised, and we believe that the data as given are substantially correct.

The omissions during the first and the last weeks in September were accidental, and the latter is particularly to be regretted, since it occurred just at the time of an outbreak. The only predisposing cause which could be found within the factory at this time was a change in the method of manufacture, which left considerable free moisture in the curd and allowed the small number of germs present to do a maximum amount of damage.

During a considerable portion of the season the red points were so small and scattering that they would have been overlooked without a magnifying glass, and even with this aid they could not always be found. At no time were they sufficiently evident to cause financial loss except in one vat on August 2 and in a half dozen vats during late September.

These favorable results were obtained notwithstanding the fact that during this time the cheese contained a high percentage of moisture and was uncolored, making the conditions very favorable for the formation and observation of blotches.

A single set of tools was used in all the vats, and the marked showing of spots in the product of one vat, while they were practically absent in the others, suggested that the inoculation of a considerable quantity of *Bacillus rudensis* was necessary in order to result in any considerable showing in the cheese.

The same observations regarding the difference in the product from different vats on the same day, which is well illustrated on August 2, could be best explained by the assumption that there was an outside source of contamination which our heating process did not reach and which at irregular intervals furnished a heavy inoculation of *Bacillus rudensis* in certain vats.

For the purpose of testing this assumption samples were collected in steamed quart fruit jars from the milk of 21 patrons on October 24 and each manufactured into a cheese with the least possible exposure to contamination. When these small cheeses were examined on November 5 red spots were fairly plenty in two and a few were found in two others.

WORK AND RESULTS AT FACTORY NUMBER FOUR IN 1902.

Method of making test cheese.— Encouraged by the results of our preliminary trial in October, 1901, we devoted considerable time to studying the method of making small cheeses in fruit jars.

This method was introduced to the dairy industry about twenty years ago by H. A. Rees, of Lowville, State Cheese Instructor, as a means of determining the quality of patrons' milk. The same method for determining the same point was more recently rediscovered at the Wisconsin Dairy School and called the Wisconsin Curd Test.

In applying this method to the determination of the presence of *Bacillus rudensis* in the patrons' milk we first carefully washed and steamed the fruit jars to destroy the germs which have remained from previous tests. Samples were collected in these jars as the patrons' milk was being emptied into the weigh can, a few drops of rennet added, the cover screwed down tightly and the can stood up in a bath of warm water. When properly thickened the curd was broken by shaking and the whey expelled by agitation and heat. When the curd was dry enough the can was opened, the whey poured off, and the curd salted and pressed by hand in small cheese-cloth bags. A quart of milk produced a cheese slightly smaller than a base ball.

Up to the time the can was opened to remove the whey the curd was entirely protected from contamination. Some chance for contamination was unavoidable during the pressing process, which was accomplished with the hands. The hands were washed before handling each cheese, and in order to determine whether *B. rudensis* was carried in this way, a record was kept of the order in which the cheeses were pressed. On comparing this order with the results of the examination of the cheese it was found that in only a small number of cases could red spots be found in the cheese handled next after those abundantly seeded with *Bacillus rudensis.*

The point of prime importance in the preparation of these cheeses was to remove a sufficient amount of water from the curd before enough acid had formed to cause the curd to "string" on the hot iron. The formation of greater quantities of acid for some reason prevented the development of spots. Since the work

was carried on without opening the cans, considerable skill was necessary, and our success varied greatly at different times. Whenever we obtained the development of a fair amount of red spots in the cheese we assumed that the milk contained *Bacillus rudensis,* but in cases where no spots appeared we could not say with certainty whether the germs were absent or had been prevented from showing by unfavorable conditions in the cheese.

Results of this test in 1902.—During the past season we have used this method of testing the milk of some of the patrons at Factory Number Four on a number of days. Our object in repeating the test was to determine, if possible, how constantly certain dairies furnished starters of *Bacillus rudensis,* and also whether there is any relation between the amounts present in the milk from the patrons and the extent of the discoloration formed in the cheese of that day.

RUSTY SPOTS IN SMALL CHEESES.

— = No red spots found.
\+ ? = Single point or points located oustide of cheese.
\+ = Less than a dozen red points found.
\+ + Points intermediate in number.
\+ + + Points very abundant.

No.	Aug. 5-6.	Aug. 21.	Aug. 22.	Aug. 23.	Sept. 4-5.	No.	Aug. 5-6.	Aug. 21.	Aug. 22.	Aug. 23.	Sept. 4-5.	No.	Aug. 5-6.	Aug. 21.	Aug. 22.	Aug. 23.	Sept. 4-5.
1	+ +	......	—	+ +	—	31	—	..	..	.....	..	61	+ +	..	—	—	..
2	......	......	—	....	..	32	—	..	..	....	..	62	+	..	—	—	..
3	......	......	......	+ +	—	33	+ ?	..	—	+ +	..	63	—	..	—	......	..
4	......	......	—	....	..	34	—	..	..	....	..	64	......	..	..	+	..
5	+ + +	......	—	+ +	—	35	....	..	..	—	..	65	—	..	..	......	..
6	+	......	—	+ +	—	36	—	..	..	....	..	66	—	..	..	......	..
7	—	......	—	....	..	37	—	..	..	....	..	67	+	—	—	+ +	—
8	—	......	......	....	..	38	—	..	..	....	..	68	—	..	..	......	..
9	—	......	......	....	..	39	—	..	..	....	..	69	—	..	—	......	..
10	—	—	......	....	..	40	—	..	..	....	..	70	......	..	..	+ + +	..
11	+ + +	......	—	+ +	+	41	—	—	..	....	..	71	......	..	..	—	..
12	......	......	—	....	..	42	—	..	..	....	..	72	—	..	..	......	..
13	......	......	......	—	..	43	—	..	..	....	..	73	—	..	..	......	..
14	—	......	......	....	..	44	—	—	..	....	—	74	+ + +	—	..	......	..
15	—	......	......	....	..	45	—	..	..	....	..	75	—	..	—	—	..
16	......	......	—	....	..	46	....	—	..	....	..	76	—	..	..	......	..
17	—	......	......	....	..	47	—	+	..	....	..	77	......	—	—	......	..
18	+ ?	......	......	+ +	..	48	—	..	—	....	—	78	......	..	..	—	..
19	—	......	......	....	—	49	—	—	..	....	—	79	—	..	..	......	..
20	+	......	—	—	..	50	....	..	—	....	..	80	—	..	—	......	..
21	—	......	......	....	..	51	+	..	—	....	..	81	—	..	..	......	..
22	—	......	......	....	..	52	—	..	..	....	..	82	......	..	..	+ + +	..
23	+	—	—	....	..	53	—	..	..	....	..	83	......	..	—	......	..
24	+ +	+ + +	+ + +	—	—	54	....	..	—	....	..	84	—	..	..	......	..
25	—	......	......	+ ?	..	55	—	..	..	....	..	85	—	..	..	......	..
26	......	......	—	....	..	56	—	..	..	....	..	86	+ ?	..	—	......	..
27	—	—	......	....	..	57	—	—	..	....	..	87	—	—	—	—	..
28	+	+ + +	—	—	..	58	—	..	..	....	..	88	......	..	..	—	..
29	—	......	......	....	..	59	—	..	..	....	..	89	......	..	..	+	..
30	—	......	—	—	..	60	....	..	..	+	..	90	......	..	..	+ + +	..

In considering these results it should be remembered that we were able to handle samples from only about one-third of the patrons on any one day.

Taking the results on different days, as shown in the above table, it will be seen that the positive results were most marked on August 5 and 6 and August 23. It so happened that there was a sharp outbreak in the factory cheese of August 5 and 6, and the samples of those days marked + + + were completely filled with closely-set red points, indicating that these dairies had furnished, on these days, a heavy starter of *Bacillus rudensis.*

Much less discoloration developed in the factory cheese of August 21 to 23, and while there was a moderate number of red points present in the samples from a considerable number of patrons on these days, the contamination in individual cases did not appear to be as heavy as on August 5 and 6.

The factory cheese of September 4 and 5 was almost entirely free from red points, and it will be observed that these were also lacking in the test cheeses of these dates.

The difference in the results of August 21 and 23 can be partly accounted for on the basis of difference of manufacture. While there were good individual cheeses on each day, the formation of acid in the cheese of August 21, taken as a whole, was too great. The cheeses of August 22 averaged much better in this respect, and those of August 23 were, everything considered, the best which we have succeeded in making.

It will be further observed that in no case did any one patron respond positively to four or more consecutive tests. This failure to respond in some cases may be ascribed to lack of success in preparing the small cheese, but these results accord well with our observations in the factory, to the effect that the introduction of *Bacillus rudensis,* at least in appreciable quantities, occurs only spasmodically. A failure to respond in three or more consecutive tests is shown in a number of instances.

WHAT IS THE SOURCE OF THE CONTAMINATION?

The presence of rusty spots in the cheese points to the factory as the source of supply of *Bacillus rudensis.*

The curd mill is a utensil peculiarly difficult to clean in the ordinary way, and our experience at Factory Number One indi-

cates that at times this may harbor a large growth of *Bacillus rudensis.* At the time of a small outbreak at Factory Number Four in 1902 red discolorations were observed on the wooden followers of the cheese hoops. The hoops, cloths and followers were thoroughly steamed, and the spots did not appear in the cheese of the succeeding days. The fact that a thorough steaming of the vats and tools rapidly cuts down the number and importance of the spots strengthens the belief that under ordinary conditions the main seed bed of infection is in the factory.

However, the sudden appearance of a large number of red points in the cheese from a single vat when the product of the remaining vats was nearly or quite free from the trouble points to an outside source of contamination. The presence of a considerable number of red points in the test cheeses made direct from the milk of the individual patrons, together with the fact that these points were especially numerous just at the time when the spots were abundant in the product of the factory, makes it fairly certain that at times considerable quantities of *Bacillus rudensis* are brought to the factory by some of the patrons.

The next step is to determine when and under what conditions *Bacillus rudensis* gains entrance to the milk. Considerable work in this connection has already been done, but the data collected were not sufficient to warrant drawing safe conclusions when the lateness of the season put a stop to this phase of the investigation.

In no case have we found evidence to warrant us in deciding whether *Bacillus rudensis* first gained a foothold in a dairy or at the factory. In either case, under ordinary conditions, the factory often offers a suitable seed bed and the germs thrive there abundantly. At the time of making the cheese a considerable number of these germs pass off with the whey. These are taken by the patrons with the whey to their farms and fed to the young animals, and in so doing the region around the barn becomes more or less seeded. The exact conditions which bring about a seeding of the milk of any dairy have not been worked out in detail. The facilities for washing the cans at the farms are not such as to insure the removal of all the germs which were in the whey, and a portion of the trouble may be accounted for in

this way. However, the appearance of *Bacillus rudensis* in the milk at such irregular intervals and at times in such quantities has led us to look for seed beds at the dairy from which occasionally the milk receives a heavy inoculation.

CONCLUSIONS AND RECOMMENDATIONS.

As the result of our experience during the past two seasons we feel assured that under all but very exceptional circumstances thorough steaming at the factory will control the rusty spots and keep them below the point where they will cause financial loss. Just as is the case with the spraying of fruit or vegetables, the success attained will depend largely upon how thoroughly the directions are followed.

In attempting to combat this trouble in any factory the first step is a thorough cleaning up of the factory and its surroundings. A few loads of gravel will do away with the mud by the weigh can and the whey tank, and good drainage should be provided for the factory waste. The walls and ceiling of the room in which the cheese is made should be cleaned and preferably whitewashed and the floor scrubbed with hot lye.

The weigh can and all the utensils which come in contact with the milk should be steamed thoroughly three times per week. This can be best accomplished by placing the utensils in a vat, drawing a heavy canvas cover tightly over the top and turning in the steam. In five minutes the heat should be up to 180° F. in all parts of the vat, and fifteen minutes more above this temperature will suffice. The weigh can is best treated by inverting and turning in the steam for twenty minutes through the faucet. The heating of the all metal cheese hoops can be carried out according to the same plan, but Frasier hoops present some difficulties. The accumulation of fat in the crevices makes a special place for heating desirable, and our experience in heating the wooden followers is not sufficient to justify us in recommending it as a regular procedure, although heating occasionally does not seem to be harmful. The observations given in connection with Factory Number Four indicate that heating these followers is desirable.

Considered both as a means of preventing the return of a considerable number of *Bacillus rudensis* to the farms and as a means of holding the whey sweet and in first-class condition for feeding, the heating of the whey to 160° F. is desirable. Unfortunately in our attempts thus far we have been compelled to stop the heating because of the leaking of the vat before we had a chance to make a fair test of its effect upon the spread of the trouble.

REPORT

OF THE

Department of Botany.

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F. A. SIRRINE, *Special Agent.*

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REPORT OF THE DEPARTMENT OF BOTANY.

TWO UNUSUAL TROUBLES OF APPLE FOLIAGE.*

F. C. Stewart and H. J. Eustace.

SUMMARY.

I. During the summer of 1902 apple leaves over the greater part of New York were much wrinkled and distorted. On the under surface they were covered with irregular blisters of various sizes caused by the separation of the lower epidermis from the mesophyll. Some of the blisters burst.

The trouble was due to heavy frosts which occurred while the leaves were partially unfolded. Ice crystals formed between the lower epidermis and the mesophyll and forced them apart. Thereafter the epidermis grew no more while the parenchyma continued to grow and arch itself into wrinkles. The damage done was unimportant.

II. In western New York there was a wide spread spotting, yellowing and dropping of apple leaves in July. This was the result of spraying with bordeaux mixture and insecticides. Because of the protracted cold, wet weather the foliage was unusually tender and susceptible to spray injury. Although at first the injury was thought to be serious it was found later that the injury was overbalanced by the good done in the prevention of scab. The spraying of apples should not be abandoned.

Observations made in this connection indicate that the disease called apple leaf spot may not be of fungous origin as heretofore believed.

*A reprint of Bulletin No. 220.

I. FROST BLISTERS ON APPLE AND QUINCE LEAVES.

DESCRIPTION OF THE TROUBLE.

During the past season an unusual and interesting disorder of apple leaves occurred throughout the greater part of New York State. About June 1 the Experiment Station began to receive inquiries from orchardists concerning a wrinkling and distortion of apple leaves. In a general way the affected leaves resembled peach leaves affected with leaf curl; so much so, in fact, that several persons inquired if the two troubles were not identical.

On the upper surface the leaves were variously wrinkled and puckered, but the under surface was fairly even and normal in appearance except for certain areas on which the color was gray green (Plates I and II). On some trees the leaves were badly distorted, with the margins drawn downward and together as if they were unable to unfold properly. Usually the wrinkles were most abundant along the mid-rib of the leaf and the elevated portions were of a somewhat lighter green than other parts of the leaf. By cutting across the leaf with scissors it was found that where the wrinkles occur the lower epidermis is separated from the green pulpy tissue (mesophyll), thus forming a large interior cavity or blister (Plate III, Fig. 1). The distance between the green tissue and the loosened epidermis was frequently as much as four millimeters (one-sixth of an inch), and the blisters thus formed were of all sizes up to those having an area of 100 square millimeters or even more. In many cases the separated epidermis became ruptured as if slit with a knife, leaving the cells of the mesophyll exposed. Sometimes the tender cells thus exposed died, causing the formation of an irregular, dead, brown spot, visible on both surfaces of the leaf (Plate II, Fig. 4). However, in the majority of cases the exposed cells remained green throughout the season.

This condition of apple foliage appears to have been general throughout New York State except in the Hudson Valley and on Long Island, where it was wholly absent. According to the reports of numerous correspondents in various parts of the State the varieties Rhode Island Greening, Baldwin and King were most affected. Observations made in the Station orchard

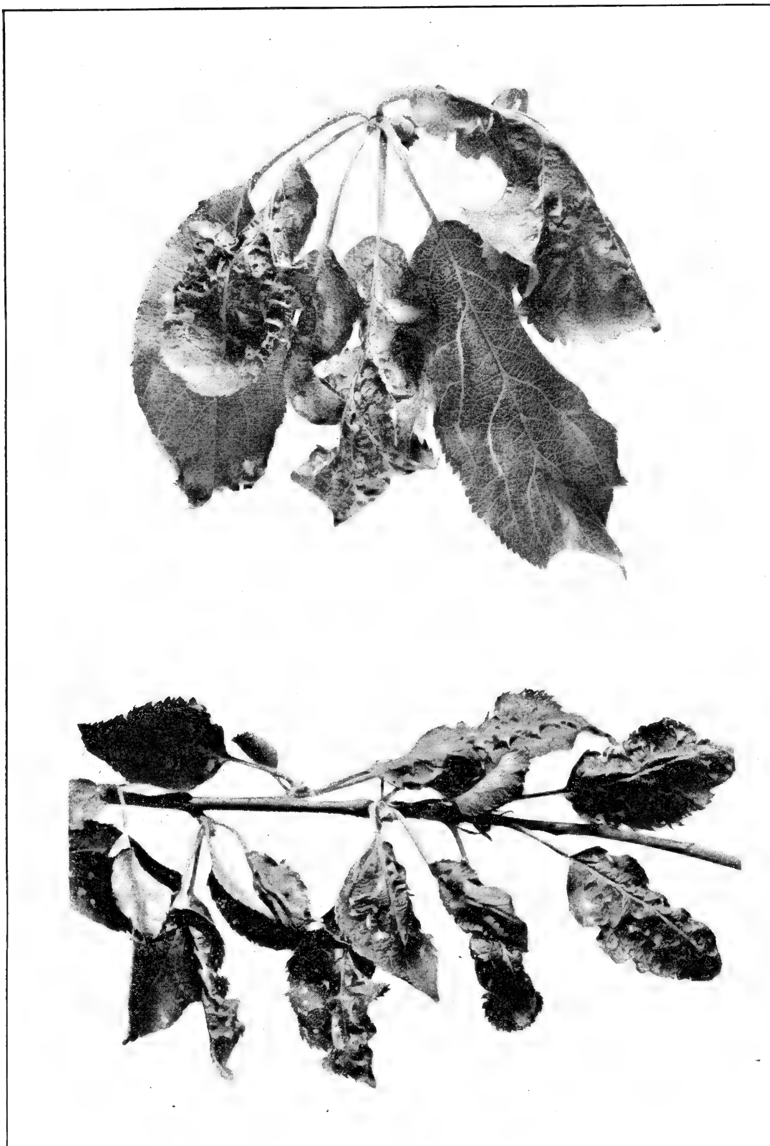

PLATE I.—APPLE FOLIAGE INJURED BY FROST.

(One-half natural size.)

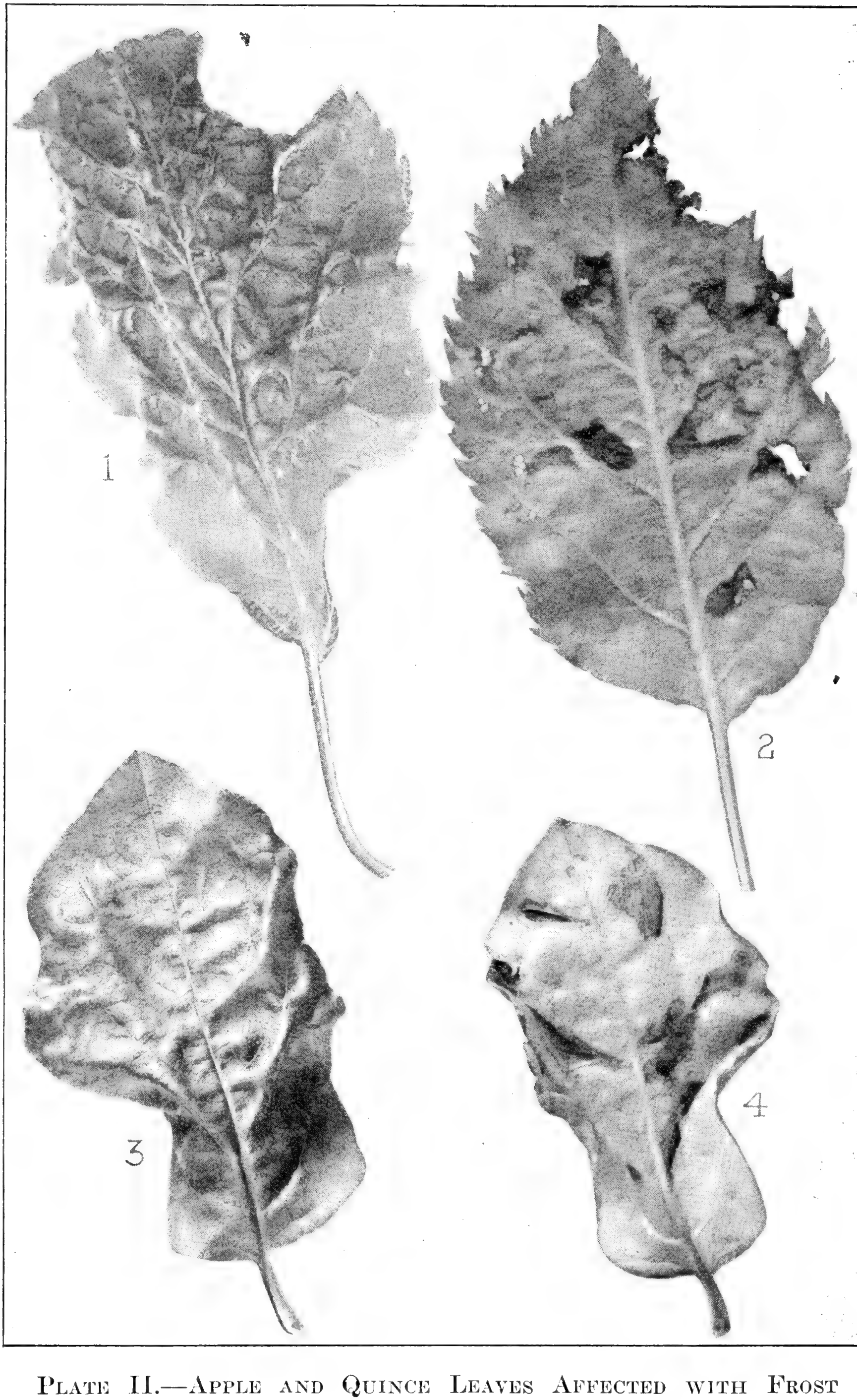

PLATE II.—APPLE AND QUINCE LEAVES AFFECTED WITH FROST BLISTER.

PLATE III.—STRUCTURE OF FROST BLISTERS ON APPLE LEAVES.

EXPLANATION OF PLATES II AND III.

PLATE II.—*Apple and quince leaves affected with frost blister.* (Nat. Size.)

FIG. 1.—*Apple leaf, upper surface.*

FIG. 2.—*Apple leaf, lower surface, showing dead, brown spots where frost blisters have broken.*

FIG. 3.—*Quince leaf, upper surface.*

FIG. 4.—*Same quince leaf, lower surface.*

PLATE III.—*Structure of frost blisters on apple leaves.*

FIG. 1.—*Cross sections of blistered apple leaves.* (Natural size. Diagrammatic. Original.)

FIG. 2.—*Cross section of blistered apple leaf.* (After Sorauer.)

June 12 show that, even under like conditions, some varieties were much more affected than others. Following is a list of the varieties examined, with notes on the degree of affection:

Unknown variety[1]	Worst of all.
Baldwin	Very abundant.
Rhode Island Greening	" "
Autumn Streaked	" "
Iowa Beauty	Abundant.
Arctic	"
Stanard	"
Ananarnoe	"
Red Canada	"
Paragon	"
Fall Pippin	"
Shannon	"
Parson Sweet	Common.
Baxter	"
Gano	"
Keswick	Some.
Northern Spy	"
Oakland	"
Titovka	"
Haywood	"
Wheeler No. 7	Traces.
Edwards	"
Summer Pippin	"
Monroe	"
Andrew Winter	Almost entirely free.
Farris	" " "
Jones Seedling	" " "
Rutledge	" " "

A tree of an unknown variety was so much affected as to strikingly resemble a peach tree attacked by leaf curl. One branch of this tree bore 458 leaves, of which 272, or 59⅓ per ct., were more or less affected. The high percentage of affected leaves on

[1] Sent to the Station under the name Western Beauty, which it certainly is not. Possibly it is Hyde's King of the West.

this tree was partly due to the fact that the tree was not making a vigorous growth of new shoots. It was an invariable rule that the leaves affected were those on the basal portion of the new shoots, while those on the middle and terminal portions were perfectly normal. In other words, the early formed leaves were affected and the later ones not. Consequently, the proportion of affected leaves became less as the season advanced and more new leaves were formed; and the more vigorous the growth the more rapidly the percentage became reduced.

Most of the affected leaves remained on the trees to the end of the season and continued to perform their function of assimilation apparently in a normal manner, excepting, of course, those instances in which dead, brown spots appeared as a result of the exposure of the cells by the rupturing of the epidermis. On some varieties a majority of the blisters became broken, while on others most of the blisters continued unbroken to the close of the season. On some varieties the breaking of the blisters usually resulted in the formation of dead, brown spots, while on others there were very few dead spots, although there were large numbers of broken blisters. Likewise individual trees of the same variety often manifested noticeable differences in both of the respects mentioned.

Trees on which the dead, brown spots formed freely shed some of their leaves from this cause, but it is unlikely that any considerable damage resulted. While the wrinkling and distortion of the leaves disfigured them, little if any real damage was done.

The dead, brown spots caused by the breaking of the blisters need not be confused with dead spots due to any other cause. While they are simply irregular, dead brown spots as viewed from the upper surface, their unusual nature is at once observed by an examination of the under surface. There, unmistakable evidence is seen of the rupturing of the epidermis, the shriveled remains of which are always plainly visible to the unaided eye. Dead spots caused by fungi or spray injury show no such evidence of the rupturing of the lower epidermis.

LATE FROST THE CAUSE.

It soon became evident to the writers that the blisters were, in some way, the result of frost injury. They were plainly not the work of fungi or insects. The fact that the trouble was widespread suggested the idea that weather conditions were responsible for it; and since it was a very unusual phenomenon, not having been previously observed in America so far as we can learn, the cause should be sought in unusual weather conditions. The spring of 1902 in New York was unusually wet and cool, and there were severe late frosts on May 10 and 11.

Wet weather might bring about œdema, and apple twigs are known to be subject to that trouble[2]; but that this was not a case of œdema is shown by the fact that the mesophyll cells, although much elongated as in œdema, were not in contact with the epidermis, and therefore could not have exerted any pressure upon it so as to cause either the wrinkles or the rupturing of the epidermis (Plate III).

The theory that the trouble was due to the frosts in May is supported by the following facts: (1) Only the early leaves, at the base of the shoot, were affected. Leaves formed after the frosts were not affected in the least. The frosts occurred while the first leaves were partially unfolded, and just before the blossoms opened. (2) It was most common in localities where the frosts were most severe, less common where the frosts were lighter, and wholly wanting in localities where there was no frost, as, for example, on Long Island. At Geneva the temperature fell to 27 degrees Fahr. on May 10 and to 26 degrees on May 11. Over the greater part of the State temperatures as low or lower than these prevailed. The following table, compiled from the May report of the New York section of the climate and crop service of the Weather Bureau, shows the minimum temperature at the various stations of the bureau in New York for May 10 and 11. In each of the two columns each temperature given is for a different station.

[2]Atkinson, G. F. Œdema of Apple Trees. Cornell Univ. Agr. Exp. Sta. Bul. 61 : 299–302

TABLE I.—MINIMUM TEMPERATURE AT VARIOUS PLACES IN NEW YORK ON MAY 10 AND 11, 1902.

SECTION	Minimum Temperature (Deg. Fahr.) for May 10.	Minimum Temperature (Deg. Fahr.) for May 11.
Western Plateau.	28. 28. 23. 26. 24. 30. 25. 28. 24. 27. 31. 25. 27. 24. 25. 26.	30. 28. 28. 24. 22. 25. 33. 25. 35. 27. 26. 27. 25. 26. 27. 27.
Eastern Plateau.	29. 22. 24. 22. 19. 33. 22. 25. 25. 24. 33. 23. 22. 24. 26. 28. 22.	29. 22. 27 23. 23. 36 20. 25. 24. 21. 27. 35. 28. 23. 22. 25. 28.
Northern Plateau.	17. 18. 17. 25. 23. 19. 20. 21. 17. 20. 22. 24.	30. 19. 23. 26. 28. 17. 21. 22. 25. 27. 23. 30.
Atlantic Coast.	34. 37. 38. 38. 39. 38.	37. 37. 43. 40. 42. 38.
Hudson Valley.	30. 24. 33. 28. 30. 35.	32. 26. 37. 31. 33. 45.
Mohawk Valley.	23. 22. 24.	26. 36. 26.
Champlain Valley.	27. 28. 27. 20. 25. 27.	31. 25. 32. 50. 26. 29.
St. Lawrence Valley.	21. 22. 20. 21.	28. 20. 30. 28.
Great Lakes.	32. 29. 33. 27. 30. 29. 29. 36. 27.	26. 28. 34. 30. 28. 31. 29. 29. 29.
Central Lakes.	26. 25. 28. 28. 25.	28. 25. 27. 27. 36.

In some localities there were also light frosts on May 12 and 14.

MANNER IN WHICH THE INJURY WAS BROUGHT ABOUT.

While the writers were endeavoring to determine the various stages in the process by which the injury was brought about and formulating a theory to account for them, there came to hand the May number of the *Zeitschrift für Pflanzenkrankheiten* containing Dr. Paul Sorauer's article "Frostblasen an Blättern"[3] (Frost blisters on leaves). Evidently Sorauer observed identically the same phenomenon on apple leaves in Germany in 1901.

According to Sorauer's view, the separation of the epidermis from the mesophyll is the result, not only of the formation of ice crystals (which he admits is a plausible theory), but also of the different degrees of expansion of different tissues when sub-

[3] Sorauer, Paul. *Zeit Pflanzankr.* 12:44–47. Mit Tafel II. May 12, 1902.

jected to a freezing temperature. The rupturing of the epidermis and the death of the cells in the brown spots he attributes to the direct action of the frost.

Our theory, which differs somewhat from that of Sorauer, is as follows: The leaves were frozen when only partially unfolded. The formation of ice crystals between the lower epidermis and the mesophyll caused these tissues to separate, and upon thawing they failed to reunite. Being removed from its source of nourishment, the epidermis then ceased growing, while the parenchyma cells continued to expand, and not having opportunity to spread out laterally, took the form of an arch, thus bringing about the wrinkles. In some cases the tension produced by the expansion of the growing parenchyma became so great that the epidermis was ruptured, and the parenchyma cells, being then exposed to the air, died from excessive transpiration. It is probable, also, that the whipping of the leaves in the wind caused the breaking of some of the blisters.

It was always the lower epidermis and never the upper one which was separated from the parenchyma. The explanation of this is probably to be found in the fact that the tissue in the lower half of the leaf is looser than that in the upper half, and consequently the lower epidermis is less firmly attached than is the upper one.

In order to determine definitely whether the rupturing of the epidermis may occur as above stated there were selected for observation thirteen blistered leaves which showed no rupturing of the epidermis. These leaves were selected and marked on June 13th. By June 24th four of the leaves showed one rupture each and one leaf showed two large ruptures. After this there was no further change to the end of the season. Although but few of the blisters broke, enough of them did so to prove conclusively that a period of at least one month may elapse between the time of the freezing and the rupture of the loosened epidermis. It is altogether likely that the breaking of the blisters was more common earlier in the season while the leaves were expanding more rapidly. The leaves marked for observation were nearly full grown at the time they came under observation.

Besides these direct observations there are several other good reasons for believing that the ruptures were not made at the time of freezing, as held by Sorauer. One of the best of such reasons is the fact that where the ruptures occur the parenchyma is invariably strongly arched. Had the rupture occurred at the time of freezing, the growing parenchyma would have been free to spread out flat in a normal manner.

It has already been stated that the breaking of the blisters and the consequent exposure of the parenchyma cells sometimes resulted in the death of the cells and the formation of dead, brown spots; while in other cases the parenchyma cells appeared to be entirely unharmed by their exposure. On June 13th an unsuccessful attempt was made to produce the dead spots artificially by rupturing the epidermis over several blisters on four different leaves. In every instance the exposed cells continued green through the remainder of the season. This was a surprise. It seemed scarcely possible that the loose, thin-walled mesophyll cells could bear prolonged exposure to the air; but it is an indisputable fact that such was the case, and hundreds or even thousands of examples of it could be found on almost any affected tree. It should be considered, however, that the season was unusually wet and cool.

It appears that the dead spots were formed early in the season. It may be that the cells when young were less able to bear exposure. We cannot agree with Sorauer that the cells were killed at the time of freezing. It is more likely that they died later from excessive transpiration after the epidermis had been ruptured. According to our observations the lower epidermis on the dead spots was invariably ruptured. The large size of some of the dead spots indicates that they enlarged considerably after the freeze, and this could not have happened had the cells been killed in freezing.

ON OTHER PLANTS.

The same phenomenon was observed on quince leaves, but to a less extent. The wrinkling of the leaves on the upper surface, the separation of the lower epidermis from the mesophyll,

the rupturing of the epidermis on some blisters while it remained intact on others, and the formation of irregular, dead. brown spots, were all practically the same as with apple leaves, the principal difference being that on the quince the majority of the blisters broke early in the season and formed dead spots. Later, portions of the dead tissue fell away, leaving ragged holes in the leaf which would have been difficult to account for by one unfamiliar with the circumstances.

Because of the close relationship existing between the apple and the pear it was expected that the leaves of the latter fruit would be found to be affected in a similar manner. However, such was not the case. No well-marked example of the trouble could be found on pear leaves. Sometimes the under surface of the leaves showed small spots gray-green in color, such as characterized the blisters on apple, but there were no wrinkles, and so far as could be determined from free-hand sections the epidermis was not loosened. Neither were there any dead spots which could be attributed to frost.

Foliage other than that of apple, quince and pear was not carefully examined. Horse-chestnut leaves were very ragged as a result of the frost, but the injury was quite different from that on apple and quince. Sorauer observed the frost blisters on cherry leaves. The writers have observed occasional cherry trees on which the foliage had evidently suffered somewhat from frost, but there was no pronounced wrinkling of the leaves and no blisters were seen.

II. SPOTTING AND DROPPING OF APPLE LEAVES CAUSED BY SPRAYING.

Early in July of the past season apple growers in western New York became considerably alarmed at an extensive spotting, yellowing and premature dropping of apple leaves. The serious condition of affairs was first brought to the attention of the Experiment Station by Mr. W. P. Rogers, of Williamson. Subsequently, several letters of inquiry concerning the trouble were received from apple growers in the counties bordering on Lake Ontario. The general tone of these letters is fairly repre-

sented by one from a fruit grower at Barker, in Niagara county. Under date of July 14, he writes:

"We are in bad shape up here. The apple leaves are all falling off. The apple trees have the leaf spot very bad, and after the rains of last week the leaves began to turn yellow and drop. It looks like November here now. As a rule, the best-sprayed orchards are most affected. Baldwins are more affected than other kinds, but all are bad."

On July 10 and 11 one of the writers, in company with the Station Horticulturist, Mr. S. A. Beach, made a tour of inspection through Wayne, Monroe and Orleans counties. At a distance the majority of the orchards appeared to have good foliage. However, there were some orchards which were evidently in bad condition. Even from the railway train it could be seen that a considerable portion of the foliage was yellow and the ground under the trees covered with leaves. Upon entering the orchards it was found that some which appeared well at a distance were in reality considerably affected with dead, brown spots on the leaves. Moreover, it was even then plain that the apple harvest would find a large percentage of the fruit affected with scab.

The conclusions reached in this investigation are set forth in the following press notice issued July 17th:

"THE YELLOWING AND DROPPING OF APPLE LEAVES.

F. C. STEWART AND S. A. BEACH.

"In many apple orchards in Western New York the leaves began to fall by July 4. In some orchards a considerable part of the foliage has fallen, and in such cases the crop may be somewhat injured. The leaves first showed dead, brown spots of various shapes and sizes, then turned yellow and fell. In some cases the fruit, also, became russeted and sometimes even cracked.

"After a careful examination of many orchards in Ontario, Wayne, Monroe and Orleans counties we have reached the conclusion that the trouble is due primarily to weather conditions and is aggravated by spraying. The protracted cold, wet weather in June made the foliage tender and susceptible to injury from the spraying liquids. Some unsprayed orchards show

a little of the trouble, but sprayed orchards are almost invariably the most affected. However, some sprayed orchards are but slightly affected. In general, cultivated and well-cared-for orchards are less affected than uncultivated and neglected ones, but there are some exceptions to this rule. While spraying under the existing weather conditions is the principal cause, it appears that several other factors enter into the problem and modify the results.

" Injury has resulted from paris green with bordeaux, ' green arsenoid ' with bordeaux, ' disparene,' or arsenate of lead, with bordeaux, arsenite of lime with bordeaux and an arsenical insecticide without bordeaux. It is clear, therefore, that each of the common insecticides has produced injury. Whether bordeaux alone is capable of doing it has not been determined.

" In the territory examined by us serious injury is not likely to result, except, perhaps, in a few of the worst affected orchards. In the majority of cases the slight injury done by spraying is likely to be overbalanced by the good done. Notwithstanding the loss of foliage in sprayed orchards it is likely that where thorough and seasonable spraying has been done the fruit will be superior to unsprayed fruit; whereas, in unsprayed orchards the damage to fruit and foliage from scab and codlin moth may be expected to increase. It would be unwise to forget the great benefits of spraying in the past and to denounce or abandon it because of the unfavorable experience of this season.

" This yellowing and spotting of the leaves considerably resembles a fungous disease common farther south and known as leaf spot; but in the present case no fungus or insect is to be found."

The trouble was at its height about the middle of July, and after July 20 it seemed to make little progress. In many orchards one-fourth to one-third of the leaves had fallen by July 20 and the leaves still remaining on the trees were badly spotted. Although unsprayed orchards were not entirely exempt from it, the sprayed orchards were almost invariably the most affected. All of the severe cases were those of sprayed orchards, and, as a rule, the more thorough the spraying the more severe the attack of leaf drop. Many of the worst affected orchards were those belonging to thoroughly up-to-date apple growers, who were, very naturally, much chagrined and perplexed. The evidence was overwhelming in favor of the theory that the spotting and dropping of the leaves was greatly increased by spraying.

Especial attention was given to a large Baldwin orchard near Williamson, in Wayne County. This orchard offered an exceptional opportunity for studying the effects of spraying because a portion of it had been sprayed and the remainder left unsprayed. The trees were about thirty years old, standing in timothy sod, and during late years have been somewhat neglected. A portion of the orchard was sprayed once, about ten days after blooming, with bordeaux mixture and paris green. The owner is unable to furnish exact information as to the composition of the spray mixture, but is of the opinion that the bordeaux contained about 15 pounds of copper sulphate to each 160 gallons, and that the amount of paris green used was 1¼ pounds to 160 gallons on some of the trees and 1½ pounds to 160 gallons on other trees. The quantity of lime necessary for the bordeaux was determined by the yellow prussiate of potash test.

At the time of our first visit to this orchard, July 10, many spotted yellow leaves were falling from the sprayed trees, while the unsprayed portion of the orchard was almost entirely free from such trouble. The contrast in appearance between the sprayed and unsprayed trees in adjoining rows was marked. The dead, brown spots were of various sizes and shapes; many were roundish or circular, with a diameter of two to three millimeters, while others were irregular in outline and larger. In all cases the line of demarcation between the living and dead tissue was sharp and the spots conspicuous. Except for the absence of pycnidia, the majority of the spots so closely resembled those of the apple leaf spot disease attributed to *Phyllosticta* spp. as to be inseparable from them. Everywhere the dead spots were of this same general character and, at this time, entirely free from *Phyllosticta* pycnidia.

The orchard was visited again on August 28. At this time there were no yellow leaves to be seen: they had fallen and disappeared. Nevertheless the contrast between the sprayed and unsprayed portions of the orchard was still striking. On the sprayed trees the leaves were badly spotted with the dead, brown spots; while on the unsprayed trees such spots were rare. Sometimes it required considerable searching to find even a single spot. One standing under a sprayed tree and looking through

the foliage toward the light could see that almost every leaf bore one or more spots. In some cases the spots were so numerous as to give the tree a scorched appearance. On the unsprayed trees it was difficult to find leaves which were affected, while on the sprayed trees it was difficult to find leaves which were *not* affected; and it was impossible to draw any other conclusion than that the *spraying was responsible for the spots.*

This discovery, although not an entirely new one, is nevertheless, important, considering that the injury was so widely spread and that spraying is almost a necessity to control apple scab and codlin moth; and an additional importance attaches to it because of the light it sheds on the nature of the disease known as apple leaf spot.

It was now observed that the majority of the spots were inhabited by a species of *Phyllosticta*[4], the characters of which agree rather closely with those given for *P. pirina* except for the color of the spores. The spores of *P. pirina* are described as hyaline, whereas in the fungus under consideration the spores appear light brown when seen in mass. Specimens of the affected apple leaves were sent to State Botanist Charles H. Peck, who writes as follows concerning them:

"ALBANY, N. Y., 6 *D.*, '02.

"Dear MR. STEWART:

"Your letter of D. 1 and inclosed apple leaves reached me in due time. I have no difficulty in finding an abundance of fertile perithecia in these specimens. The species is certainly not *Phyllosticta limitata,* and I doubt if it is *P. pirina,* though it comes near it. The spores of that are said to be *hyaline,* but in these specimens they are too decidedly colored to be properly described as hyaline. According to my measurement they are also broader than given for *P. pirina* spores, but just right for length. I should say they are 4–5 μ long, 2.5–3.5 broad. The peculiar saprophytic habit may have had an influence in modifying the character of a species that would on a normal habitat have been a good Phyllosticta. It makes an approach to Sphæropsis in its

[4]Intermingled with the *Phyllosticta* pycnidia were smaller bodies of various sizes resembling pycnidia to the unaided eye, but which, under the microscope, proved to be merely knots of short brown hyphæ with nothing to prove their identity. They may have been immature *Phyllosticta* pycnidia. Tufts of *Macrosporium* sp., also, were occasionally found on the spots.

colored spores, but in size of perithecia and spores it is more like Phyllosticta. My opinion is that it is an anomalous Phyllosticta, just hovering between that genus and Sphæropsis. If I was dealing with it I should at least make it a variety of *P. pirina,* but probably it would be better to make it a distinct species.

"Very truly yours,

"CHAS. H. PECK."

Surely the fungus is not far removed from *P. pirina.* With the casual observer it would generally pass for that species.

Since this *Phyllosticta* is certainly a saprophyte, why may not the closely related *P. pirina* and *P. limitata* also be saprophytes? Their parasitism has never been proven by inoculation experiments, and, in certain respects, their behavior is such as to lead to the suspicion that they are not parasites. For example, a fungous leaf disease of this sort is, theoretically, preventable by spraying with fungicides; but observations along this line indicate that such is not the case either with *P. pirina* or *P. limitata.*

Lamson[5], speaking of *Phyllosticta pirina,* says: "As in previous years the bordeaux mixture has seemed to have but little effect on this disease." One of the writers[6] has reported an instance in which an apple tree sprayed three times with bordeaux suffered severely from leaf spot disease (*Phyllosticta limitata*). On Long Island, where the leaf spot disease is abundant nearly every season, it is the common experience of orchardists that spraying does not prevent leaf spot.

Another fact suggesting the non-parasitism of *Phyllosticta limitata* is the tardy appearance of pycnidia. Although the spots may appear as soon as the leaves are expanded, they are usually destitute of pycnidia until July or later. In fact, a large percentage of the spots never show pycnidia.

On the same date that the *Phyllosticta* pycnidia were discovered on the spots caused by spraying there were collected from an unsprayed orchard at Williamson some Baldwin apple leaves bearing the same kind of roundish, dead, brown spots (Plate IV, Fig. 3). These spots were sparingly inhabited by the same

[5]Lamson, H. H. N. H. Agr. Exp. Sta. Bul. 48:146.
[6]Stewart, F. C. N. Y. Agr. Exp. Sta. Rep. 15:455. 1896.

saprophytic *Phyllosticta* as that found on the spray-injury spots and by no other fungus which could have caused the spots[7]. What was the real cause of the spots we are not prepared to say, but it is very improbable that they were due to any fungus. And yet they were typical examples of the apple leaf spot, except for the absence of the species of *Phyllosticta,* to which the disease is commonly ascribed.

If we proceed on the assumption that the apple Phyllostictas are not parasites, we must account for the origin of the spots in those cases in which they occur on unsprayed trees, as they unquestionably often do occur. This is one of the problems yet to be solved. A possible explanation which suggests itself is that when a shower is followed by bright sunshine drops of water on the leaves act as lenses and concentrate the sun's rays to such an extent as to overheat the tissues underneath. At any rate, it is entirely possible that the spots are in some way the result of atmospheric influences. Duggar[8] has cited an instance in which sunshine following rain caused the shot-hole effect in peach leaves.

So far as known to the writers, the parasitism of the apple Phyllostictas has not been previously questioned. In the past the presence of *Phyllosticta* pycnidia on circular, dead brown spots on apple leaves has been considered conclusive evidence that the spots were caused by the *Phyllosticta,* and the disease has been promptly diagnosed as leaf spot. In the future the problem of determining the cause of such spots on apple leaves will be a more difficult one. It is our opinion that at least a large part of the so-called apple leaf spot is due to spray injury and weather conditions and is not of fungous origin.

Returning, now, to the situation in western New York, it may be said that the prediction that the sprayed orchards would have the advantage at the close of the season, in spite of the injury done to the foliage, became a fact. When it came time to gather and market the fruit it was found that there was an unusually large amount of scab. In many unsprayed orchards the entire crop was so scabby as to be almost worthless. Even

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[7]There were, however, large numbers of small, brown hyphal knots like those associated with the spray-injury spots. See foot-note on page 71.

[8]Duggar, B. M. Proc. of the Soc. for the Promotion of Agr. Sci. 19:69. 1898.

EXPLANATION OF PLATES IV AND V.

PLATE IV.—*Dead, brown spots on Baldwin apple leaves.* (Nat. size.)

FIGS. 1 AND 2.—*From the Williamson orchard mentioned on page 70. Spots caused by spraying: bearing* Phyllosticta *pycnidia.*

FIG. 3.—*From an unsprayed orchard at Williamson. Cause of spots unknown. Spots, in all respects, apparently identical with those caused by spraying. They bear pycnidia of the same* Phyllosticta.

PLATE V.—*Greening apples russeted and cracked by spraying.* (Photographed natural size, July 12, 1902.) *On one side of each apple the skin was rough and russet brown in color and there was a deep wide crack in the flesh; but there was no evidence of the presence of any fungus, which goes to show that the trobule was not due to scab, which is the usual cause of the cracking of apples. When scab is present it shows itself in the form of spots covered with a greenish black mold.*

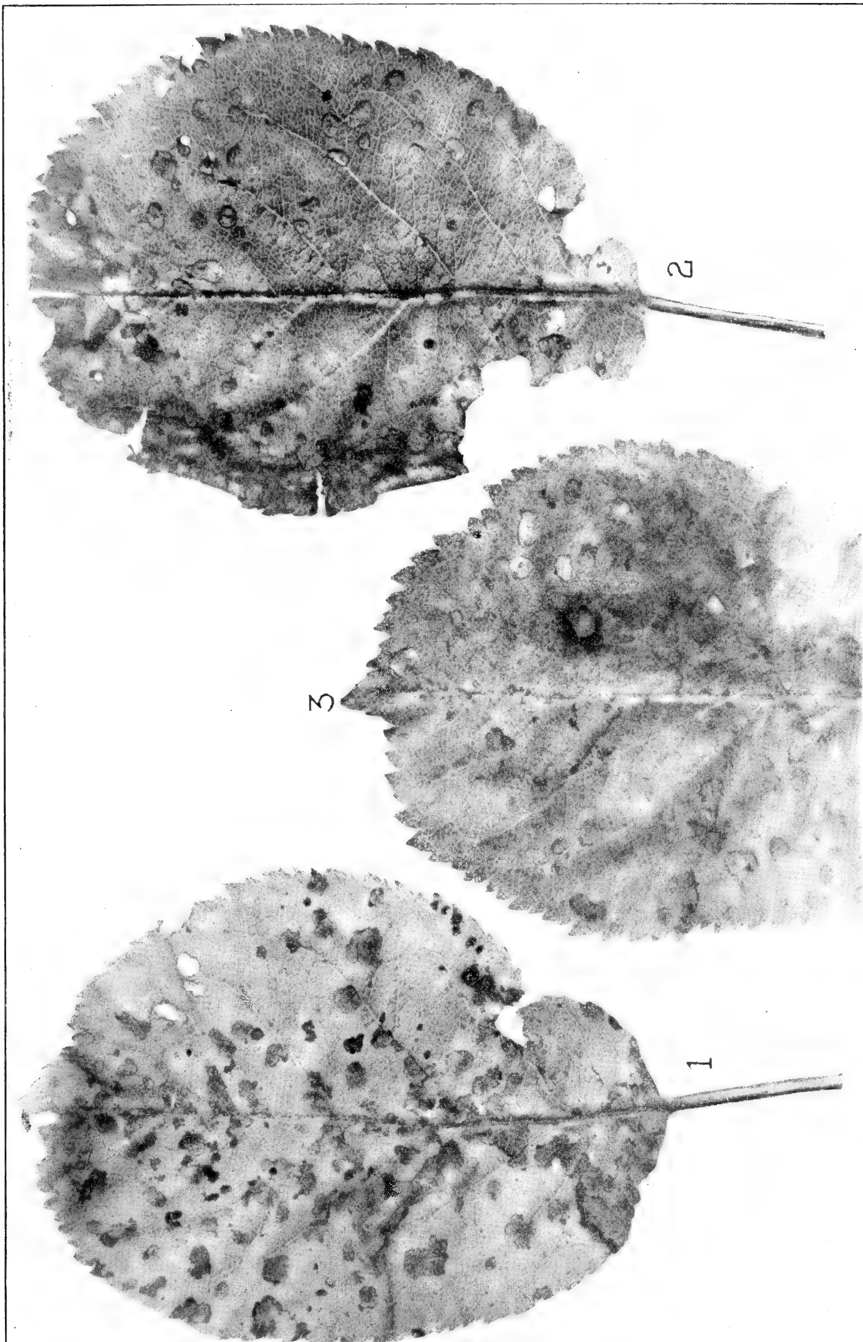

Plate IV.—Dead, Brown Spots on Apple Leaves.

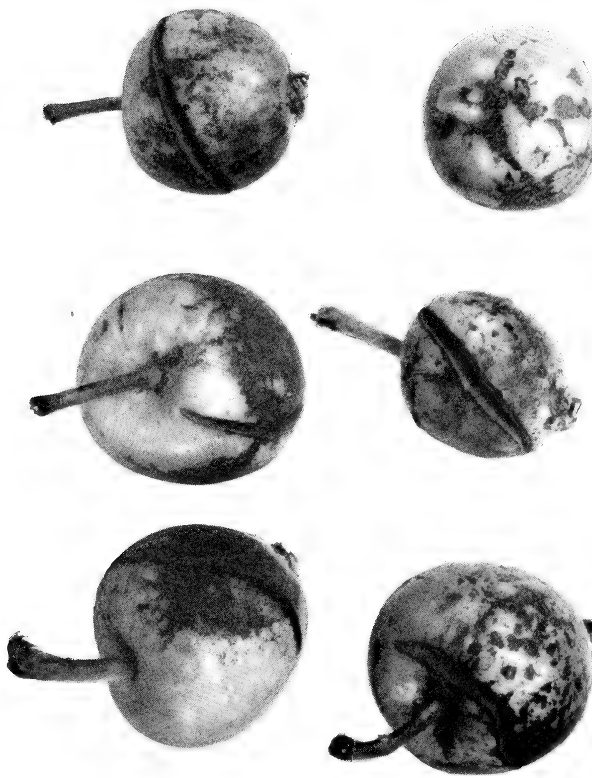

PLATE V.—GREENING APPLES RUSSETED AND CRACKED BY SPRAYING.

in sprayed orchards there was considerable scab. Scabby fruit is always less salable than clean fruit, and during October there developed a destructive and unusual kind of rot[9] which brought scabby fruit into such ill repute that many buyers refused to handle it at any price. Many owners of unsprayed orchards found themselves possessed of large quantities of scabby fruit for which there was no sale. In most well-sprayed orchards, on the contrary, there was a fair amount of clean salable fruit; and so, notwithstanding the injury to the foliage, it is probable that spraying proved profitable in the majority of cases, although a few orchards were so severely injured by spraying that the crop was ruined.

At the close of the season, and with the data all before us, we are still of the opinion that it would be unwise to abandon the spraying of apples because of the unfavorable experience of the past season. There is no doubt that the foliage will sometimes be injured even when the spray mixtures are properly prepared and applied, but it is rare that the injury will be as severe as it was in 1902. So far as we can learn, there is no previous record of such widespread and serious damage from spraying. On the other hand, the ravages of scab and codlin moth are considerable nearly every season and often practically ruin the crop. The only successful method of fighting these pests is by spraying, which must be practiced if fine fruit is to be expected.

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[9]This rot was caused by the fungus *Cephalothecium roseum* and attacked only scabby apples. It will be fully discussed in a bulletin of this Station to be issued soon. A brief preliminary account of it appeared in *Science* 16:747. 7 N. 1902. The day on which this Bulletin went to press, December 16, Cornell Experiment Station Bulletin No. 207 was received. It is entitled, "Pink Rot: An Attendant of Apple Scab," and consists chiefly of a discussion of the rot above mentioned. However, a part of page 168 treats of the injury to apple foliage by spraying. The authors state that wherever lime was added to the bordeaux mixture in excess of the required amount the injury was correspondingly lessened. Accordingly, they recommend that, "in rainy seasons at least twice the regular amount of lime should be used in making a bordeaux mixture."

POTATO SPRAYING EXPERIMENTS IN 1902.*

F. C. STEWART, H. J. EUSTACE AND F. A. SIRRINE.

SUMMARY.

The Station has undertaken to determine how much the yield of potatoes may be increased, on the average, by spraying the plants with bordeaux mixture for ten consecutive seasons; also, which is more profitable, to spray every two weeks throughout the growing season, or to make but three applications. The experiments are to be carried on in two localities; viz., on the Station farm at Geneva and on Long Island. At each place the area of the experiment field is to be three-tenths of an acre each season. Each year, or as often as advisable, there will be published a bulletin giving the results up to date; also other information on the spraying of potatoes.

The present bulletin gives the results of the first year's work. At Geneva, the rows sprayed three times yielded at the rate of 317½ bushels per acre; those sprayed seven times 342½ and those not sprayed, 219. Thus, three sprayings increased the yield 98½ bushels per acre and seven sprayings, 123½ bushels. The increased yield on sprayed rows was due, chiefly, to the prevention of late blight.

On Long Island the rows sprayed three times yielded at the rate of 295⅓ bushels per acre; those sprayed seven times, 312½ and those not sprayed, 267⅔. The increased yield due to three sprayings was 27⅔ bushels per acre, while that due to seven sprayings amounted to 45 bushels yer acre. There being no damage from blight or "bugs," the increased yield on the sprayed rows in the Long Island experiment must have been largely due to better protection against flea-beetles.

*A reprint of Bulletin No. 221.

INTRODUCTION.

For more than fifteen years it has been known that potato blight may be prevented by spraying the plants with bordeaux mixture. Potato spraying experiments have been made by the United States Department of Agriculture, by many of the experiment stations and in Europe. With but few exceptions these experiments have shown that the yield of potatoes may be considerably increased by spraying, and it is the concensus of opinion among experts, that, under most conditions, the spraying of potatoes is a profitable operation. The results of these experiments and the conclusions deduced from them have been widely published in various publications of the United States Department of Agriculture, in experiment station bulletins, in the agricultural papers and through the medium of farmers' institutes.

Nevertheless, there is probably no place in the United States where the spraying of potatoes is generally practised by farmers — certainly none in New York State. In New York very few farmers spray their potatoes regularly. In seasons when the blight is epidemic, as it has been during the past season, many attempt to protect their potatoes by spraying, but in most cases only partial success is attained because the spraying is commenced too late and not done thoroughly. Evidently, farmers in this State are not yet convinced that it pays to spray potatoes regularly. As nearly as we are able to determine, the causes of this unbelief in the profitableness of potato spraying are as follows:

(1) Blight is not destructive every season. While occasionally it nearly ruins the crop, there are other seasons when it does but little damage, and still others when there seems to be no damage whatever. Consequently, farmers look upon spraying as a matter of insurance. While they readily admit that there is profit in spraying in seasons when potatoes blight badly, they do not believe that it pays on the average.

(2) In many cases the spraying is not done thoroughly, and consequently the results are unsatisfactory.

(3) Few farmers who spray potatoes know accurately how much they have increased the yield by spraying. Usually no portion of the field is left unsprayed; hence there is no basis for comparison except the unsprayed fields of neighbors. Even where a few rows are left unsprayed for comparison the difference in yield is usually guessed at and rarely determined accurately by weight or measurement.

(4) Often there is a lack of confidence in the results obtained at experiment stations. Many persons believe that in experiments made at the stations the potatoes have been given an extra chance, and that it is impossible to duplicate the results in ordinary farm practice.

DETAILS OF THE EXPERIMENTS.

OBJECTS.

The chief object of the experiments herein reported was to ascertain how much the yield may be increased, *on the average,* by spraying potatoes in New York State. With this point definitely determined, it will be considerably easier to give a correct answer to the question, Does it pay to spray potatoes reguarly? Since the profit to be derived from spraying depends upon the relation existing between the expense of the treatment and the value of the increase in yield due to the treatment, the ideal experiment would be one which takes both of these factors into account; but in order that the test might be a fair one, so far as the expense is concerned, it would be necessary to have several acres included in the experiment. This would have made more work than it was deemed advisable to undertake, and so it was decided to attempt only the solution of the simpler but more important part of the problem; namely, the average increase in yield. We consider the question of increase in yield more important for the reason that it varies greatly from year to year, whereas the expense of spraying varies but little in different seasons.

It is possible that next season the Station will undertake some supplementary experiments especially designed to determine the expense of spraying.

A second object of the experiments was to determine which is the more profitable: To spray every two weeks throughout the season, as is usually recommended; or to make only three sprayings during the season.

DURATION.

Of course it is necessary to continue the experiments several years before a reliable average can be obtained. The chief cause of variation in the results is the variation in weather conditions, and since the average weather conditions for any period of ten years approximate very closely the average for any other period of ten years, it would seem that the proper length of time to continue the experiments is ten years. Accordingly, the Station expects to spray potatoes every year for ten consecutive years, and the plan of the experiments each year will be the same as in this first year's work. Each year the increase in yield per acre due to spraying will be accurately determined, and at the end of the ten years the results will be averaged.

However, it is not the intention to withhold the publication of the results until the experiment is finished. Each year, or as often as seems advisable, there will be published a bulletin giving a detailed account of the results of unpublished experiments and a summary of the results of the preceding years, in order that the public may be kept informed as to the progress of the experiments. These bulletins will also contain other matter pertaining to potato spraying and potato blight. Therefore, this bulletin is the first of a series on the subject of potato spraying.

LOCATION OF EXPERIMENT FIELDS.

In some localities potatoes blight more frequently and more severely than in others, and, consequently, spraying produces a larger increase in yield in some localities than in others. On this account it was thought best to conduct the experiments in at least two localities. One of the places selected was on the Experiment Station farm at Geneva, and the other on the farm of Mr. F. A. Sirrine, three miles north of Riverhead, on Long

Island. Throughout the entire period of ten years during which the experiments run the experiment fields will be confined to these same two farms, but, of course, not on the same plats.

ARRANGEMENT AND AREA OF PLATS.

In order to eliminate as far as possible the influence of inequalities in the soil, etc., the plats were arranged in the manner shown in the accompanying diagram:

DIAGRAM SHOWING ARRANGEMENT OF PLATS IN THE EXPERIMENT AT GENEVA.

	O. A.	
Section A.	1.	Sprayed 3 times.
	2.	Sprayed 7 times.
	3.	Unsprayed.
Section B.	4.	Sprayed 3 times.
	5.	Sprayed 7 times.
	6.	Unsprayed.
Section C.	7.	Sprayed 3 times.
	8.	Sprayed 7 times.
	9.	Unsprayed.
Section D.	10.	Sprayed 3 times.
	11.	Sprayed 7 times.
	12.	Unsprayed.
Section E.	13.	Sprayed 3 times.
	14.	Sprayed 7 times.
	15.	Unsprayed.
	O. B.	

Rows O. A and O. B were really not in the experiment. They were planted in order to avoid having any *outside* rows in the experiment. Otherwise the rows 1 and 15 would not have had an equal chance with the other rows.

Series I consisted of rows 1, 4, 7, 10 and 13, which were sprayed three times.

Series II consisted of rows 2, 5, 8, 11 and 14, which were sprayed seven times.

Series III consisted of rows 3, 6, 9, 12 and 15, which were not sprayed.

The area of the experiment field at Geneva was exactly three-tenths of an acre, and of the one at Riverhead the same.

At Geneva the rows were 290.4 feet long and 3 feet apart. Hence each row contained exactly one-fiftieth of an acre and each series one-tenth of an acre.

At Riverhead the rows of the different series alternated with each other, as at Geneva; but in this case there were 12 rows 363 feet long and 3 feet apart. Each row contained one-fortieth acre and each series, consisting of four separate rows, one-tenth acre.

FITTING, PLANTING, CULTIVATION, ETC.[1]

At Geneva.— In the season of 1901 part of the field grew corn and part cow peas. In the spring of 1902 the land was plowed and sown with oats before it was decided to use it for the potato experiment. On May 16, furrows were opened with a plow and commercial fertilizer[2] applied in the furrows at the rate of 1,000 pounds per acre. The fertilizer was worked in with a hoe.

The seed was of the variety Rural New Yorker No. 2, which is one of the most popular varieties in central New York. The seed pieces used were whole tubers of the size of a hen's egg. A short time before planting they were given the formalin treatment[3] for scab. They were planted on May 16 and 17, 15 inches apart in the row, the rows 3 feet apart, and covered with a hoe. The cultivation was all done with a horse cultivator, which was used five times. In the last cultivation the dirt was thrown toward the plants so as to hill them slightly. There was no hand cultivation except the pulling of a few large weeds late in the season.

The soil was a black, clay loam with a clay subsoil. The field sloped gently toward the east, giving good drainage.

At Riverhead.— The previous crop for two years had been timothy and weeds. The land was plowed six to eight inches

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[1] These cultural details, although somewhat irrelevant, are given here for the reason that many persons desire to know how yields of 325 and 350 bushels per acre were obtained in the experiment at Geneva while potato yields in the surrounding country ranged from 25 to 100 bushels per acre.

[2] The fertilizer used was from a lot which was in one of the Station barns when they were destroyed by fire on May 7. Before the fire the fertilizer analyzed as follows: Potash, 4.59 per ct.; nitrogen, .83; available phosphoric acid, 14.11. Its market value was about $26 per ton.

[3] Tubers soaked two hours in a solution containing one pint of formalin in 30 gallons of water.

deep on April 13 and then harrowed three times. After treatment with corrosive sublimate for scab, planting was done by hand on April 23 with whole tubers of the size of a hen's egg, placed 15 inches apart in the row and the rows 3 feet apart. The variety of potato was Carman No. 1, which is very popular on eastern Long Island. Home-mixed fertilizer, having the formula 4-10-4 and costing $27.20 per ton, was used at the rate of 1,100 pounds per acre. The trenches for planting were made by going twice over each row with a fertilizer drill, and the tubers were covered with the discs of an Aspinwall potato planter. A cultivator was used once and a weeder once before the plants came up. After the plants were up the weeder was used twice and the cultivator six times. At the last cultivation the plants were slightly hilled. A few weeds were pulled and a few cut out with a hoe. The soil was well-drained sandy loam containing some gravel, and the field sloped moderately toward the southeast.

PREPARATION AND APPLICATION OF THE BORDEAUX MIXTURE.

The methods of preparing and applying the bordeaux mixture were practically the same at Geneva and at Riverhead. The bordeaux was made according to the 1-to-8 formula; that is, one pound of copper sulphate was used in each eight gallons of bordeaux, or six pounds to the barrel. This is the formula usually recommended for spraying potatoes. The amount of lime required was determined by the yellow-prussiate-of-potash test.

The bordeaux was applied by means of a knapsack sprayer, except in the first spraying (June 25) at Geneva, in which case it was applied with a barrel pump, such as is used for spraying trees.

The spraying was done with great thoroughness, particularly at Geneva. No attempt was made to spray the under surface of the leaves, but practically every leaf was well coated above. When the plants became full grown the foliage of adjacent rows intermingled, and thus it was impossible to thoroughly spray the rows of series I and II without getting some of the mixture on the adjacent unsprayed rows of series III. However, this was avoided as much as possible.

DATES OF SPRAYING.

At Geneva: Series I.— This series, consisting of rows 1, 4, 7, 10 and 13, was sprayed three times with bordeaux mixture — July 10, 23 and August 12. The applications were made at such times as they were most needed. It was impossible to delay the first application longer than July 10, because at that time large numbers of "bugs"[4] had commenced to feed, and unless these had been killed at once they would have done great damage. To kill the "bugs," paris green was added to the bordeaux mixture at the rate of 10 ounces to 50 gallons. The treatment was entirely successful. Five days later there was scarcely a living "bug" to be seen.

It was thought advisable to make the second spraying on July 23, because during the preceding week there had been frequent showers and the weather seemed favorable to blight. In fact, the occurrence of late blight (*Phytophthora*) had already been reported from Delhi (July 15) and Ilion (July 21). In this second spraying bordeaux alone was used.

Late blight made its first appearance in the experiment field on July 28. At this time the disease was already epidemic among early potatoes at Geneva, Seneca Falls and other places in central New York; but it was not yet common among late potatoes, and in the experiment field it made slow progress even on the unsprayed rows.

The third and last spraying was made August 12 with bordeaux alone.

Series II.— This series consisted of rows 2, 5, 8, 11 and 14. It was the intention to spray it according to the directions usually given for spraying potatoes; namely, "Commence spraying when the plants are six to eight inches high and repeat the treatment at intervals of 10 to 14 days as long as the plants remain green."

In all, seven sprayings were made, as follows: June 25, July 10, 23 and 30, August 12 and 26, and September 10. Paris green

[4]The word "bugs" as used throughout this bulletin refers to the striped Colorado potato beetles, *Doryphora decemlineata.* Properly speaking these insects are beetles, not bugs, but to farmers they are known as "bugs." Moreover, "bugs" is a shorter name and for that reason it will be used in this bulletin.

was used in only one spraying, that of July 10, in which case it was used at the rate of 10 ounces to 50 gallons, as on series I, and with equally good results. On account of the weather conditions being exceptionally favorable to late blight during the week following July 23 it was considered advisable to spray on July 30, although only a week had elapsed since the last spraying. However, subsequent events showed that this was unnecessary. It might just as well have been postponed until August 6, which would have made the interval between sprayings two weeks, as originally planned. Had this been done, the next two sprayings would each have occurred one week later, and the seventh spraying might then have been omitted.

Series III.— Series III consisted of rows 3, 6, 9, 12 and 15. They were not sprayed at all with bordeaux, but were treated twice (July 10 and July 30) with paris green in lime water to kill the "bugs." The paris green was used at the same rate as on series I and II; that is, at the rate of 10 ounces to 50 gallons of water. Although the "bugs" were practically all killed by the application made July 10, the same as on series I and II, sprayed with bordeaux, it was necessary to make a second application to series III on July 30; whereas, series I and II required but the single treatment for "bugs." However, the "bugs" were so completely controlled by the two treatments that they did not harm the plants.

At Riverhead: Series I.— This series consisted of four rows — Nos. 2, 5, 8 and 11, which were sprayed with bordeaux mixture three times; namely, on May 26, June 20 and July 22. No poison was used except in the second spraying, when "green arsenoid" was added to the bordeaux at the rate of 5 ounces to 50 gallons.

Series II.— This series consisted of four rows — Nos. 1, 4, 7 and 10. They were sprayed with bordeaux mixture seven times; namely, on May 26, June 3, 20 and 30, July 11 and 23, and August 5. "Green arsenoid" was added to the bordeaux on June 20 (5 ounces to 50 gallons), on June 30 (6 ounces to 50 gallons), on July 8 (8 ounces to 50 gallons), and on July 23 (5 ounces to 50 gallons). There was no necessity for using poison on this series to kill "bugs," because there were none

worth mentioning; but flea-beetles were plentiful and poison was used frequently in an attempt to kill them. Their ravages were certainly lessened and some dead flea beetles were actually found.

Series III.— Series III also consisted of four rows — Nos. 3, 6, 9 and 12. This series was not sprayed at all with bordeaux mixture and only once (July 11) with poison, consisting of 8 ounces of "green arsenoid" in 50 gallons of dilute lime water. There were so few "bugs" that the average farmer would have considered it unnecessary to apply poison.

THE RESULTS OF THE EXPERIMENTS.

AS INDICATED BY THE CONDITION OF THE FOLIAGE.

At Geneva.— Potato "bugs" did no appreciable damage to any of the plats. Twice they appeared in large numbers, but were promptly killed before they did any damage, and thus their ravages were practically eliminated from the experiment.

A few "bugs" were observed at the time of the first spraying of series II (June 25), but it was not thought necessary to poison them. They first appeared in destructive numbers about July 9. On that date it was found that many colonies had hatched and were just commencing to feed. On this account the entire field was treated on July 10. On series I and II the paris green was added to the bordeaux, and on series III it was used alone in lime water. The "bugs" were nearly all killed. On July 15 the only living "bugs" which could be found were a few full-grown beetles. The old ones appear to be more difficult to poison.

As late as July 23 only an occasional "bug" could be found, but on July 25 a new brood began to hatch, and it was observed that they were nearly all on the rows of series III, which had not been sprayed with bordeaux. In view of the fact that the paris green applied on July 10 had killed the "bugs" about equally well on all three plats, it is worthy of note that the new brood appeared almost entirely on series III. It appears that the old beetles shunned the plants covered with bordeaux and laid their eggs only on the unsprayed rows.

On July 30 the "bugs" were so numerous on the unsprayed rows that they would soon have done much damage unless killed, and hence it was necessary to treat series III a second time with paris green in lime water. As there were no "bugs" on the other two series, no paris green was used on them, but series II was sprayed for blight with bordeaux alone. The treatment for "bugs" on series III was effective. They were nearly all dead the following day and there was no further trouble from "bugs" during the remainder of the season.

The punctures of flea beetles[5] were fairly abundant as early as July 10, but little damage was done by these insects until toward the close of August, at which time they attacked the unsprayed rows and hastened, somewhat, the death of the plants. The sprayed rows were practically free from flea-beetle injury.

The plants suffered neither from drought nor from wet weather, and there was no early blight, *Alternaria solani*. Late blight, *Phytophthora infestans*, first appeared on the unsprayed rows July 28, but made slow progress. On August 25 the unsprayed rows began to look a little brown, as viewed by one standing at the end of the field. Upon entering the field and making a closer examination it was found that the unsprayed plants had a trimmed-up appearance, due to the death of many of the lower leaves. There were also some yellow leaves. At the same time the foliage on the sprayed rows was practically perfect, there being only occasionally a blighted leaf. The lower leaves, clear to the ground, were alive and perfect and none yellow. The color of the sprayed plants was a darker green than that of the unsprayed plants. There was, apparently, no difference between the plants sprayed three times and those sprayed every two weeks.

During the last week in August the unsprayed plants deteriorated rapidly and the contrast in appearance between the sprayed and unsprayed rows became marked. This was due to the combined attacks of late blight and flea-beetles. However, as late as August 28, one month after the first appearance of blight, scarcely any of the plants had died, although they commenced to die very soon after that date.

[5]*Crepidodera cucumeris.*

On September 4 the contrast between the sprayed and unsprayed rows was very marked. Many unsprayed plants were entirely dead, while on many more one-third to one-half of the foliage was dead, and all of the plants had lost their lower leaves. For the first time there now appeared to be a slight difference between the rows of series I (sprayed three times) and those of series II (sprayed every two weeks). The latter were still almost perfect in foliage, while the former showed a considerable number of blighted leaves and also some yellow leaves.

On September 10 practically all of the unsprayed plants were dead. A few plants still had a few green leaves at their tips. Both sprayed series now showed many leaves browned at the tips, and there was somewhat more of this on series II than on series I. Miscroscopic examination showed that this tip browning was chiefly due to some other cause than Phytophthora. In the majority of cases no Phytophthora could be found. Only a few dead stalks were found on the sprayed rows.

An interesting observation made at this time was that stalks from the sprayed rows lopping over to the ground in the direction of the adjacent unsprayed row were usually dead; whereas stalks from the same rows lopping on the ground in the opposite direction, toward a sprayed row, were still green.

By September 16 the plants on series I and II had commenced to die. Many stalks were brown and on almost every hill there were indications that growth was nearly ended.

By September 22 the unsprayed plants were all dead and their stems mostly dry. On the sprayed rows about 25 per ct. of the plants still had sufficient foliage to enable them to make some growth, but this date is to be considered as practically the close of the growing period of series I and II. The difference between the two series was so slight as to seem unimportant.

On all of the unsprayed rows, and on the sprayed rows as well, the plants died very irregularly, some earlier and some later, making it difficult to determine the exact time at which the plat as a whole was to be considered dead. Hence it was difficult to determine exactly how much the sprayed plants outlived the unsprayed plants. However, it may be said that the sprayed plants were in somewhat better condition on September 22 than the

unsprayed plants were on September 10, making the period of growth for the sprayed plants at least twelve, and probably fourteen, days longer than that of the unsprayed plants. It should also be noted that the sprayed plants were in almost full foliage until within a short time of their death, and were thus able to assimilate at their full capacity throughout the greater part of their life. The unsprayed plants, on the contrary, lost many of their leaves early in the season and their power of assimilation was greatly decreased.

At Riverhead.— In the experiment at Riverhead, "bugs" gave practically no trouble. There were only traces of early blight and no late blight. Nevertheless, the sprayed plants lived several days longer than the unsprayed plants. This is owing to the fact that flea beetles were rather plentiful at times and injured the unsprayed plants most.

On August 11 the contrast in color between the sprayed and unsprayed rows was so marked that it could be plainly seen at a distance of one-half mile. At this date, there was still a little green foliage on series I, sprayed three times, and on some of the plants the tubers were probably growing a little. Only a few stalks were dead and dry.

On series II, sprayed seven times, about one-third of the foliage was yet alive and the tubers must have been growing considerably. The lower leaves were mostly dead, but plants entirely dead were rare. While the plants on this series were considerably injured by flea-beetles, they were not nearly as bad as the plants on series I, sprayed three times, or on series III, unsprayed. A considerable portion of the increased yield on series II is attributable to better protection against flea-beetles. At the same time, the plants on series III, unsprayed, were all dead and about forty per ct. of the stems were dry.

AS SHOWN BY THE YIELD.

At Geneva.— The potatoes were dug on September 26, 27 and 30. At that time the majority of the stems on the sprayed rows were still succulent, but growth had ceased except in an occasional plant. The unsprayed plants were all dead and the stems dry.

The potatoes were dug by hand and care taken to lose none. The product of each row was sorted into two grades, marketable tubers and culls, and the weight of each grade taken. All tubers larger than a hen's egg were graded as marketable. The sorting was nearly all done by the writers and as uniformly as possible.

TABLE I. YIELDS IN THE EXPERIMENT AT GENEVA.

Section.	Row.	TREATMENT.	YIELD PER ROW.				YIELD PER ACRE.			
			Marketable.		Culls.		Marketable.		Culls.	
			Lbs.	*oz.*	*Lbs.*	*oz.*	*Bu.*	*lbs.*	*Bu.*	*lbs.*
A.	1.	Sprayed 3 times....	388	11	31	6	323	54	26	8
	2.	Sprayed 7 times....	427	2	25	8	355	56	21	15
	3.	Unsprayed........	282	14	29	8	235	43	24	35
B.	4.	Sprayed 3 times....	394	14	26	14	329	3	22	23
	5.	Sprayed 7 times....	411	8	26	9	342	55	22	8
	6.	Unsprayed........	250	9	35	0	208	48	29	10
C.	7.	Sprayed 3 times....	360	2	29	12	300	6	24	47
	8.	Sprayed 7 times....	413	3	25	9	344	19	21	18
	9.	Unsprayed........	271	11	26	10	226	24	22	17
D.[6]	10.	Sprayed 3 times....	427	8	15	0	356	15	12	30
	11.	Sprayed 7 times....	389	13	21	1	324	50	17	33
	12.	Unsprayed........	276	8	32	2	230	25	26	40
E.	13.	Sprayed 3 times ...	360	13	20	4	300	40	16	52
	14.	Sprayed 7 times....	392	11	22	2	327	14	18	26
	15.	Unsprayed........	246	7	30	10	205	21	25	31

Comments on the table.—An examination of the above table reveals the following: (1) In each of the five sections the sprayed rows yielded more than the unsprayed row, the least difference

[6] It will be observed that row 10 (sprayed 3 times) yeilded at the rate of 21½ bu. per acre more than row 11 (sprayed 7 times). There is surely some error here, but it has been impossible to account for it. It is not in the weighing. Because of this discrepancy it will be necessary to leave section D, comprising rows 10, 11 and 12, out of consideration in making up the average yields.

being in section C, where the three-sprayed row 7 yielded only 74 bushels per acre more than the unsprayed row 9. The greatest difference between a three-sprayed row and an unsprayed row in any one section (barring section D, in which there is evidently an error) is in section B, where row 4 yielded 120¾ bushels per acre more than row 6.

(2) In every case, except in section D, the seven-sprayed row yielded more than the adjacent three-sprayed row in the same section, the difference being least in section B, where it was 14 bushels per acre, and greatest in section C, where it was 44 bushels per acre.

(3) The yield of rows receiving the same treatment varied considerably in different portions of the field. With the unsprayed rows the greatest difference was 30 bushels per acre; with the three-sprayed rows, 29 bushels; and with the seven-sprayed rows, 29 bushels. These differences seem to have been due chiefly to differences in severity of attack by blight. The blight started in section E next an oat field which bordered the potato field on one side for about one-half its length. The damage done by blight was noticeably greater here than in any other part of the field.

Yield by series.— The four rows sprayed three times constitute series I[7], and the average yield of these four rows make the yield of series I. The yields given for series II and III were computed in the same manner. The yield by series is shown in the following table, in which the results of the experiment are reduced to their simplest terms.

TABLE II. YIELD BY SERIES AT GENEVA.

Series.	Rows.	DATES OF SPRAYING.	Yield per acre.	
			Bu.	*lbs.*
I . . .	1, 4, 7, and 13.	July 10, 23 and August 12.	317	41
II . . .	2, 5, 8 and 14. .	June 25, July 10, 23, 30, August 12, 26 and September 10.	342	36
III. . . .	3, 6, 9 and 15. .	Not sprayed.	219	4

[7] Rows of Section D omitted because of manifest error.

Increase in yield due to spraying three times, 98 1-2 bushels per acre.

Increase in yield due to spraying seven times, 123 1-2 bushels per acre.

Considering that the difference in the appearance of the foliage on series I and II was very slight, we were surprised to find the difference in yield so large as 25 bushels per acre.

The loss from rot.—Although there had been considerable late blight (*Phytophthora*) on all of the unsprayed rows and a little also on the sprayed rows, the tubers were found to be but little affected with rot. On the sprayed rows only an occasional rotten tuber was found, and even on the unsprayed rows the number was not large. Most of the affected tubers were completely rotten. Very few showed the early stages of the disease.

In order to determine, approximately, the amount of the loss from rot, the number of rotten tubers was counted on row 12, an unsprayed row which probably suffered as much from blight as any other row in the field except row 15. The number of rotten tubers was found to be 134. Unfortunately, the number of sound tubers in row 12 was not determined, but assuming it to be the same as on the unsprayed row 6, where the number was 1,628, the loss from rot was 7.6 per ct. In size the rotten tubers appeared to average about the same as the sound ones. This would make the loss from rot on the unsprayed rows about 18 bushels per acre, which is small, considering that the tops were so badly blighted. Had the conditions been more favorable for rot it is likely that the difference in yield between the sprayed and unsprayed series would have been considerably greater.

At Riverhead.—The potatoes were dug on August 29 and 30 by hand and carefully and uniformly sorted into marketable tubers and culls. On the sprayed rows growth had ceased, the leaves being nearly all dead, but many of the stems were still green and more or less succulent. The unsprayed plants were entirely dead and the stems dry.

TABLE III. YIELDS IN THE EXPERIMENT AT RIVERHEAD.

Section.	Row.	TREATMENT.	YIELD PER ROW.		YIELD PER ACRE.	
			Marketable.	Culls.	Marketable.	Culls.
			Lbs.	*Lbs.*	*Bu.*	*Bu.*
A.	1.	Sprayed 7 times....	501	40½	334	27
	2.	Sprayed 3 times....	465	37½	310	25
	3.	Unsprayed	412½	76	275	50⅔
B.	4.	Sprayed 7 times....	467½	35½	311⅔	23⅔
	5.	Sprayed 3 times....	441½	42	294⅓	28
	6.	Unsprayed	389½	52	259⅔	34⅔
C.	7.	Sprayed 7 times....	428½	36	285⅔	24
	8.	Sprayed 3 times....	458½	39	305⅔	26
	9.	Unsprayed........	385½	76	257	50⅔
D.	10.	Sprayed 7 times....	478½	35	319	23⅓
	11.	Sprayed 3 times....	407	41½	271⅓	27⅔
	12.	Unsprayed	418½	51	279	34

Comments on the table.— The most notable feature of this table, as compared with the table of yields for Geneva on page 90, is the smaller difference in yield between sprayed and unsprayed rows. This is due to the fact that in the experiment at Geneva late blight and rot wrought considerable havoc among the unsprayed plants, while in the experiment at Riverhead there was no attack of late blight. At Riverhead the increased yield of the sprayed rows was chiefly due to better protection against flea beetles and to the stimulating effect of bordeaux on the foliage. There was no disease to combat in this experiment except, perhaps, a small amount of early blight.

In section C, row 8, sprayed three times, yielded at the rate of 20 bushels per acre more than row 7, sprayed seven times. In section D, row 12, unsprayed, yielded eight bushels per acre more than row 11, sprayed three times. These are plainly inconsistencies which we are unable to explain. Possibly they are due to errors in weighing, but we think not. Great care was exercised

to give the rows an equal chance in every respect except in the matter of spraying, but, somehow, error crept in. This is an illustration of the inaccuracies which may occur even in the most carefully planned and carefully managed field experiments.

Yields by series.—The yield by series is shown in the following table:

TABLE IV. YIELD BY SERIES AT RIVERHEAD.

Series.	Rows.	DATES OF SPRAYING.	Yield per acre.	
			Bu.	*lbs.*
I....	2, 5, 8 and 11..	May 26, June 20 and July 22..............	295	20
II....	1, 4, 7 and 10..	May 26, June 3, 20, 30, July 11, 23 and Aug. 5.	315	35
III....	3, 6, 9 and 12..	Not sprayed..............................	267	40

Increase in yield due to spraying three times, 27⅔ bushels per acre.

Increase in yield due to spraying seven times, 45 bushels per acre.

Loss from rot.—At Riverhead there was no loss from rot, not even on the unsprayed rows.

AS SHOWN BY CHEMICAL ANALYSIS.

With the potato the question of quality is less important than with many other vegetables and fruit. For the most part, potatoes are potatoes so far as their food value and cooking qualities are concerned, although it is true that some varieties are recognized as being preferable to others in these respects; also, tubers grown in certain localities where the soil is supposed to be especially suited to the potato command a somewhat higher price. For a given variety buyers usually have a uniform price, except for lots in which the tubers are scabby or much out of the ordinary size. In short, sprayed potatoes sell for the same price as unsprayed ones, because consumers recognize no difference between them.

As for the effect of spraying on the quality of the tubers, it appears to be simply a question of maturity. When a potato plant dies prematurely from blight its tubers must of necessity be

less mature than those of sprayed plants which grew two or three weeks longer. The difference in the degree of maturity between the tubers of sprayed and unsprayed plants depends, of course, upon the length of time the life of the plants is prolonged by spraying. In those cases in which the unsprayed plants are killed early in the season, while the sprayed ones grow on to the close of the season and die naturally, it seems as if the difference in the maturity of the tubers might be sufficiently great to materially affect their food value. In order to get light on this subject it was suggested by Director Jordan that a chemical analysis be made of tubers from sprayed and unsprayed plants in the experiment at Geneva.

Accordingly, there were taken fifty consecutive hills from a row sprayed seven times (row 8) and fifty other hills from the adjoining unsprayed row (row 9) and the entire product placed at the disposal of Director Jordan, under whose direction the analyses were made. Following is Dr. Jordan's account of the results:

"As stated in the foregoing, there was placed in my hands the product of fifty hills of potatoes sprayed seven times and of fifty hills unsprayed. Both lots were weighed, counted and analyzed. The results appear in the following table:

CHARACTER AND COMPOSITION OF SPRAYED AND UNSPRAYED POTATOES.

YIELD AND SIZE OF TUBERS.

TREATMENT.	Number of Tubers in 50 Hills.			Tubers in one hill.	Total weight of tubers.	Average weight of tubers.
	Merchantable.	Unmerchantable.	Total.			
					Lbs.	*Ozs.*
Sprayed potatoes...	345	78	423	8.46	94.2	3.56
Unsprayed "	263	79	342	6.84	67.4	3.15

COMPOSITION OF TUBERS.

Lab. No.	TREATMENT.	Water.	Dry matter.	Ash.	Protein.	Nitrogen free compounds.	Starch.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
4134	Sprayed potatoes ...	76.	24.	.9	2.2	20 9	16.8
4133	Unsprayed "	77.4	22.6	.9	2.4	19.3	15.9

"These data disclose the following facts:

"(1) The sprayed potatoes yielded more tubers to the hill and of larger average size than the unsprayed.

"(2) Spraying apparently had the effect of increasing the dry matter of the tubers. This increase is seen to consist mostly of starch, the excess of dry matter in the tubers from sprayed potatoes being 1.4 per ct., and of starch 1.1 per ct.

"Other things being equal, the food value of a vegetable or fruit is proportional to its digestible dry matter. As the increase from spraying is seen to be almost wholly starch, and as this carbohydrate is practically all digested, it is reasonable to conclude that the sprayed potatoes are about 7 per ct. more valuable for human food than the unsprayed.

"For the same reasons and to the same extent the sprayed potatoes would be worth more to manufacturers of starch."

THE PROFIT.

At Geneva.— For the reasons given on page 79 no attempt was made to keep an account of the expense of spraying in the experiment. Nevertheless, it is worth while to consider briefly the probable profit.

In central and western New York the market price of potatoes during October was about 50 cents per bushel. Early in November the experiment potatoes were actually sold for 60 cents per bushel. Spraying three times increased the yield 98½ bushels per acre. At 50 cents per bushel this increase is worth $49.25. Judging from previous experience, it is our opinion that spraying as thorough as in this experiment could be done on a commercial basis at an expense not greater than $2 per acre for each spraying, or $6 for three sprayings. This allowance is certainly ample. On Long Island, in 1896, the Station sprayed eight acres of potatoes at a total expense of 80 cents per acre for each application[8]; but, of course, the work was not done as thoroughly as at Geneva. Under proper management and with a supply of water reasonably accessible, potatoes may be sprayed at a total expense of $1 per acre for each application. Besides, it should not be forgotten that at least one, and usually two, applications

[8]See Bul. No. 123 of this Station, page 241.

of poison are required to keep the Colorado potato beetles, or "bugs," under control. In this particular experiment it was necessary to use paris green twice on the unsprayed rows to kill "bugs." Probably this could not have been well done for less than 50 cents per acre for each application, or $1 per acre for two applications. In fairness, this $1 should be deducted from the $6, leaving $5 as the extra expense per acre due to spraying.

The increase in yield per acre due to seven sprayings was 123½ bushels, having a value of $61.75. Allowing that the extra expense of the seven sprayings was $13 per acre, there is left a net profit of $48.75 per acre.

At Riverhead.— In the experiment at Riverhead the Station had an agreement with Mr. Sirrine to pay him for all expense of the spraying, labor being rated at 20 cents per hour. Mr. Sirrine's bill for labor and chemicals was $2.42 for the three sprayings of series I and seven sprayings of series II, making the actual expense of spraying $2.42 per acre for each application. Of course this expense is proportionally higher than it would be where fields of several acres are sprayed with a horse sprayer. As already stated, $2 per acre is ample allowance for the expense of spraying as thoroughly as was done in these experiments.

On Long Island the price of potatoes during September, the month in which the principal part of the crop of late potatoes is dug, ranged from 25 to 55 cents per bushel. The experiment potatoes were stored and actually sold in December for 65 and 75 cents per bushel. The increase in yield per acre due to three sprayings was 27⅗ bushels, worth, at 40 cents per bushel, $11. Deducting from this the sum of $6, the expense of the three sprayings, there is left a net profit of $5 per acre.

The increase in yield per acre due to seven sprayings was 45 bushels, worth $18. Deducting $14 as the expense of the seven sprayings, there is left a net profit of $4 per acre.

CONDITION OF THE POTATO CROP IN NEW YORK IN 1902.

In central and western New York the potato crop of 1902 was light. Prolonged wet weather delayed planting, and many fields afterward suffered from an excess of rain. The rains also hin-

dered cultivation. Early varieties blighted and rotted badly during the latter part of July, making it necessary to dig and market them at once. Late potatoes became quite generally affected with late blight during the last week in July and the first week in August, and many fields were entirely dead by September 1. During August and September the weather was drier than in July and much less favorable to blight. In fact, after about August 10 the weather was such that it is unlikely that blight would have done any appreciable damage had it not been that the fields were already thoroughly seeded with the disease. As it was, the foliage of all unsprayed potatoes was considerably injured by late blight, but there was only a slight amount of rot found among the tubers at digging time.

From all sections, except Long Island, small yields were reported. In the vicinity of Geneva yields as high as 100 bushels per acre were rare. From 50 to 75 bushels per acre were the common yields, while yields as low as 25 bushels per acre were frequently reported and occasionally fields were found not worth digging.

In the central and western portions of the State it appears that late blight and "bugs" were practically the only troubles of potato foliage. There was no early blight, and flea-beetles did only slight damage late in the season. In some sections "bugs" were reported unusually troublesome. Many farmers found it almost impossible to kill them with paris green in water. Some used it at the rate of two or three pounds to 50 gallons of water, making two or three applications; and even then the bugs did much damage. Such heavy applications of paris green are likely to have injured the foliage unless lime water was used with it.

On Long Island, particularly in the eastern portion, the potato crop was unusually heavy. In the western portion there was a little blight and rot, while in the eastern portion there was no late blight worth mentioning, very little early blight, and "bugs" were about as troublesome as usual. Flea-beetles and tip burn did some damage. Yields of 300 bushels per acre were very common, while yields of 350 to 400 bushels per acre were occasionally reported.

CAN FARMERS OBTAIN AS GOOD RESULTS?

Some persons are inclined to question the reliability of the results obtained in potato spraying experiments like those reported in this bulletin. They doubt that such results can be duplicated in ordinary farm practice. It cannot be denied that such doubts are, to a certain extent, justified, and, therefore, it is worth while to devote some space to a discussion of this subject.

In the experiment at Geneva the yields obtained were so far above those obtained by farmers in the surrounding country as to arouse curiosity concerning the methods of culture employed. On this account the methods have been given in full on page 82. Even on the unsprayed rows the average yield per acre was 219 bushels, or about double the best yields obtained by farmers in the vicinity. In seeking to account for this large yield on unsprayed rows several have called attention to the fact that fertilizer was used at the rate of 1,000 pounds per acre, and expressed the opinion that this quantity was excessive and larger than a farmer could afford to use. On many farms, already rich in fertility, it would no doubt be wasteful to apply fertilizer at the rate of 1,000 pounds per acre for a potato crop; but in the experiment at Geneva the condition of the land was such that the application of that quantity seemed justified. By a fortunate accident it was made possible to determine accurately the benefit obtained from the use of the fertilizer. In weighing out fertilizer for the experiment, the two outside rows, O. A and O. B (see diagram on page 81) were forgotten and no allowance of fertilizer made for them. The result was that these two rows were planted without fertilizer. Throughout the season they were treated in exactly the same manner as the unsprayed rows in the experiment. They received no bordeaux mixture, but were treated with paris green for "bugs" at the same time as the unsprayed rows. When the potatoes were dug row O. A, without fertilizer, yielded at the rate of 137 bushels per acre, while the nearest unsprayed row, row 3, with fertilizer, yielded at the rate of 235 bushels per acre. On the other side of the field, row O. B, without fertilizer, yielded 100 bushels per acre; while the

neighboring unsprayed row, row 15, with fertilizer, yielded 205 bushels per acre. Thus it appears that the use of 1,000 pounds of fertilizer per acre increased the yield about 100 bushels per acre. The value of the fertilizer used was $13, while 100 bushels of potatoes were worth $50, and the net profit from the use of the fertilizer was $37 per acre. Certainly it would have been false economy not to have used the fertilizer.

As for the experiment at Riverhead, where fertilizer was used at the rate of 1,100 pounds per acre, it need only be said that on Long Island that quantity is considered moderate, and Station experiments have shown 1,000 pounds per acre to be profitable[9]. Many potato growers use one ton per acre and believe that it is profitable.

Another objection raised by potato growers in central and western New York is that the potatoes were planted in drills, which, of course, tends to increase the yield, but on many farms is impractical, owing to the difficulty of keeping the crop free from weeds. Many farmers plant from 33 to 36 inches apart each way, which admits of horse cultivation in both directions.

On land foul with weeds it would probably be unwise to plant in drills; for, no doubt, considerable hand labor would be required, especially in wet seasons. However, it should be the aim to prevent land from becoming foul. On the Station farm it is the policy to keep weeds under control, and, consequently, no difficulty whatever was experienced in keeping the potatoes clean by ordinary horse cultivation.

We do not consider the objection to planting in drills well founded. By a little extra care, year after year, weeds may be kept under control to such an extent that it will be possible to plant potatoes in drills and keep them free from weeds without employing hand labor. Where potatoes can be planted in drills it is desirable to do so, since the yield can be greatly increased thereby at little extra expense.

As to the use of whole small tubers for seed little need be said. The object was to secure a full stand in order to have uniform conditions throughout the experiment; and a full stand is more readily obtained with whole tubers than with pieces. However,

[9] Bulletins Nos. 93, 112, 137, 154 and 187 of this Station.

it is not generally considered a good practice to plant whole small tubers.

Another objection is the small scale upon which the experiment was made. Each series had an area of one-tenth acre and each row one-fiftieth acre. There is every reason to believe that the yields were actually as large as stated. The product of each row was accurately weighed to an ounce and the land accurately measured. But it must be admitted that so small an area has advantages over large ones. In the first place, almost every large field has a certain amount of poor or waste land which cuts down the average yield; whereas, a small field can be so located that there will be no waste land. Secondly, with a small field it is possible to plant, spray, cultivate, etc., always at the proper time, which is not possible for large fields.

The spraying was done more thoroughly than most farmers would do it, and since the success of spraying depends largely upon the thoroughness with which it is done, it is likely that the benefits from spraying in the experiment were greater than they would be from spraying done by the average farmer. However, the thoroughness of spraying was partially offset by the fact that the diseased foliage of unsprayed rows often intermingled with the foliage of sprayed rows, subjecting them to greater danger of infection than would be the case where a whole field is sprayed. Also, the alternation of sprayed with unsprayed rows made the progress of the disease less rapid among the unsprayed plants than it would have been in unsprayed fields, where the disease could pass from one plant to another across rows as well as lengthwise of them. In the experiment infection among the unsprayed plants must have spread chiefly lengthwise the rows.

No matter in what way a large yield is brought about, whether by the use of large quantities of fertilizer, by thick planting, extra cultivation or the use of productive varieties, the benefits from spraying will be correspondingly increased. That is to say, a field of potatoes which without spraying would yield but 100 bushels per acre, would not give as large returns for spraying as would a field capable of producing 200 bushels per acre without spraying. In the Geneva experiment, with potatoes which yielded 219 bushels per acre without spraying, three sprayings

increased the yield 98½ bushels per acre. Had these same three sprayings been applied to fields near Geneva which yielded only 100 bushels per acre without spraying, it is unlikely that the yield would have been increased as much as 98½ bushels per acre; but just how large an increase might be expected in such a case is not clear[10]. Of course much depends on the cause of the low yield. If it were chiefly due to the ravages of insects or blight the case would be quite different from what it would be if there were errors in culture or a lack of fertility. Spraying cannot be expected to correct errors in culture or take the place of fertility.

With the ravages of blight and insects the same, it seems probable that the maximum benefit from spraying is to be obtained in potato fields in which all other conditions are most favorable to a large yield.

While an increase of 98½ bushels per acre is to be considered an excellent return for three sprayings, the amount is not as great as it might have been had the blight been as severe in the experiment field as it was in many other fields around Geneva. In some respects the conditions for getting large returns were exceptionally good in the experiment, but on the whole it seems as if up-to-date potato growers, who employ correct cultural methods, fertilize liberally and spray properly, should have done equally well during the past season.

DOES IT PAY TO SPRAY POTATOES?

To give a positive answer to this question would be to anticipate the results of the long series of spraying experiments just

[10]The best information on this subject available is furnished by a farmer living about five miles northwest of Geneva. He sprayed 12 acres of potatoes three times with a power sprayer which sprayed five rows at a time with one nozzle per row. One row through the center of the field was left unsprayed. This row was dug separately and the yield carefully measured. The same was done with an adjacent sprayed row. It was found that the sprayed row outyielded the unsprayed row by a trifle more than three bushels. Since sixteen rows were required to make an acre, the increase in yield amounted to over 48 bushels per acre. The yield on the unsprayed row was at the rate of 110 bushels per acre and on the remainder of the field about 160 bushels per acre. He estimates that on the twelve acres spraying increased the yield by nearly 600 bushels of potatoes having a value of $300. Of this sum at least $235 was clear profit.

In this case the spraying could not have been thoroughly done, and consequently the results are not strictly comparable with those obtained in the experiment on the Station farm; but they show what can be done by farmers under average conditions. Unquestionably, there are hundreds of farmers in central and western New York who could have made $20 per acre net profit by spraying their potatoes last season.

begun at the Station. However, it may be said that the writers themselves already have decided opinions on the subject. The object of the experiments is to produce evidence which shall be so conclusive that farmers generally will be convinced and practice spraying.

It is our opinion that it *does* pay well to spray potatoes. In some seasons it pays much better than in others, but, if properly managed, it will not result in loss in any season. Many persons think that spraying is useful only in preventing blight and rot. This is a mistake. Numerous experiments show that spraying increases the yield considerably, even when the plants are not attacked by blight. Bordeaux mixture stimulates the potato leaves to produce more starch. Then, too, it has been shown that "bugs" and flea-beetles are kept more thoroughly under control by spraying with bordeaux mixture than by any other method. Farmers certainly do not realize how great is the damage done by "bugs" and flea-beetles. The common methods of fighting these insects are not as effective as they should be. For the most part flea-beetles go unchecked. "Bugs" are poisoned with paris green, which is either applied in dry form by means of a powder gun or in water by means of a sprinkler. By either method a large proportion of the "bugs" usually escape and the plants are more or less stripped of their leaves. In many cases the paris green treatment is applied two or three times and large quantities of the poison used. Still the "bugs" thrive, while the foliage is often seriously injured by the paris green. Paris green applied dry almost always does some injury to the foliage. The same thing often happens when it is used in pure water, but when it is used in lime water the foliage is not injured. Of course "bugs" *can* be thoroughly controlled with paris green, but as a matter of fact they usually are not controlled, and considerable damage results.

When potatoes are sprayed three times or more with bordeaux mixture there is no trouble with "bugs," no damage done by them, and there is no paris green injury to the foliage. All that is necessary is to add paris green to the bordeaux at the rate of one-half to three-fourths of a pound to each 50 gallons of bordeaux. Spraying also prevents a considerable part of the dam-

age done by flea-beetles. They are not entirely controlled, but their ravages are materially lessened. Thus, spraying obviates the necessity of fighting "bugs" and flea-beetles.

Fairly thorough spraying can be done at a total expense of $1 per acre for each application. At this rate three sprayings would cost $3. The returns which may be expected from such spraying are 25 to 100 bushels per acre increase in yield. In any season the increased yield will cover the expense of spraying, and in most seasons there will be a large net profit.

DIRECTIONS FOR SPRAYING.

Commence spraying when the plants are six to eight inches high and repeat the treatment at intervals of about two weeks as long as the plants continue green. Usually six applications will be required. The bordeaux mixture should contain six pounds of copper sulphate to each 50 gallons. Whenever "bugs" or flea-beetles are plentiful add paris green at the rate of one-half to three-fourths pound to 50 gallons of bordeaux. Thoroughness of application is to be desired at all times, but is especially important when flea-beetles are numerous or the weather favorable to blight. When a horse sprayer is used there should be two nozzles for each row.

Those who wish to get along with three sprayings should postpone the first one until there is danger of injury from "bugs" or flea-beetles, and then spray thoroughly with bordeaux and paris green. The other two sprayings should likewise be thorough and applied at such times as to keep the foliage protected as much as possible during the remainder of the season. Very satisfactory results can be obtained from three sprayings.

A single spraying is far better than none, and will always be profitable, but more are better. There is no excuse for using paris green alone for "bugs." Whenever it is necessary to fight insects use bordeaux containing paris green.

RASPBERRY CANE BLIGHT AND RASPBERRY YELLOWS.*

F. C. STEWART AND H. J. EUSTACE.

SUMMARY.

I. Cane blight is a disease of raspberries which causes the plants, either wholly or in part, to suddenly die, about the time the fruit is ripening. It is caused by a fungus which attacks the canes at some point, killing and discoloring the bark and wood, thereby causing the death of the parts above. It occurs more or less abundantly, and often destructively, in most of the raspberry plantations in New York. It attacks nearly all varieties of the raspberry, both red and black, and perhaps also the dewberry; but the blackberry is exempt.

Inoculation experiments have shown that it is caused by the fungus *Coniothyrium* sp. Both new and old canes succumb to inoculation within two months. Natural infection occurs on new canes during summer and autumn, and, probably, also on fruiting canes in the spring. Infection often takes place in wounds, particularly those made by the snowy tree cricket and in "heading back" the new canes.

The fungus is disseminated by means of infected nursery stock; by wind, rain and washing of the soil; and in picking, pruning and laying down the canes.

The bluish-black areas so common on new canes of red raspberry in August and September, and once thought to be the early stage of cane blight, are now believed to be due to the fungus *Sphaerella rubina* and comparatively harmless. Perhaps this is Miss Detmar's bacterial disease.

In an experiment at Charlotte, N. Y., Cuthbert raspberries sprayed three times during the spring with bordeaux mixture

*A reprint of Bulletin No. 226.

gave an average yield of $185\frac{1}{4}$ pints per row, while unsprayed rows in the same plantation averaged $203\frac{1}{2}$ pints. The spraying might have been more successful had it been commenced the previous summer.

No definite and effective line of treatment has yet been established. Among several precautions to be observed the most important are: (1) To secure healthy plants with which to start the plantation; (2) to remove the old canes immediately after the fruit is gathered.

II. Yellows is a name proposed for a raspberry disease which is believed to be chiefly responsible for the so-called running out of the variety Marlboro in the Hudson Valley. It is characterized by stunted growth, mottled yellowish-green foliage and dry, insipid fruit. The cause and remedy are both unknown. In an experiment at Marlboro, N. Y., plants sprayed thirteen times were as much affected as unsprayed plants.

INTRODUCTION.

It is the intention of the writers to publish, at some future time, a complete account of the diseases of the cultivated raspberries, blackberries and dewberries. Studies on this subject have been in progress about three years. It will be at least a year, and perhaps longer, before the work can be completed, and for that reason it is thought best to publish now some of the results which, it is believed, will be of interest to fruit growers.

I. RASPBERRY CANE BLIGHT.

HISTORY, DISTRIBUTION AND BIBLIOGRAPHY.

Raspberry cane blight first came to our attention in 1899 while prosecuting a fruit-disease survey of the Hudson Valley. Although abundant and destructive and evidently not new to fruit growers, the disease was, nevertheless, entirely unknown to science at that time. It seems strange that so conspicuous and widespread a disease should so long have escaped the attention of plant pathologists.

In the season of 1900 our observations were extended to central and western New York where the disease was again found

in abundance, and further observations made in 1901 and 1902 indicate that it occurs more or less abundantly in a majority of the raspberry plantations throughout New York State.

Concerning the prevalence of the disease in other states there is, as yet, very little definite knowledge. Through the kindness of Prof. A. D. Selby we have obtained positive evidence of its existence in Ohio. Dr. W. C. Sturgis, formerly botanist of the Connecticut Experiment Station, sent us specimens of the disease from Connecticut in 1900 with the statement that it was destructive there. It has undoubtedly been observed in Wisconsin by Mr. W. C. Thro, a nursery inspector, who kindly sent us typical specimens of the disease collected at Janesville, Wisconsin, in 1900. However, Mr. A. L. Hatch, an observant fruit grower of Sturgeon Bay, Wis., writes that he is unfamiliar with any raspberry disease of this description. Prof. F. D. Chester, of the Delaware Experiment Station, informs us that a destructive raspberry disease having the general symptoms of our cane blight occurred in Delaware in 1901; but the specimens which he sent bore none of the fungus (*Coniothyrium*) which is the cause of cane blight. It is possible that these specimens were cut off above the point of attack.

It is believed that the following articles constitute the bibliography of the disease at the present time:

1899. Stewart, F. C., & Blodgett, F. H. A Fruit-Disease Survey of the Hudson Valley in 1899. N. Y. Agr. Exp. Sta. Bul. 167: 305-307.

1900. Stewart, F. C. Fruit Diseases in the Hudson Valley in 1899. Proc. Fourth Ann. Meeting of the Eastern N. Y. Hort. Soc., p. 27.

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1901. Stewart, F. C. Plant Diseases. Proc. Forty-sixth Ann. Meeting of the Western N. Y. Hort. Soc., p. 84.

1901. Ibid. Report of the Committee on Plant Diseases. Proc. Fifth Ann. Meeting of the Eastern N. Y. Hort. Soc., pp. 28, 29.

1901. Thro, Wm. C. Report of Nursery Inspection in Wisconsin for 1900: concluded. *The Wisconsin Horticulturist.* Vol. VI, No. 2, p. 31, Apr. 1901. Baraboo, Wis.

1902. Stewart, F. C. Sudden Dying of Raspberry Canes. *American Agriculturist,* 70:100. Aug. 2, 1902.

All of the above articles are brief, the most important ones being the first and the third.

DESCRIPTION.

Both red and black raspberries are attacked, but on red varieties the symptoms are somewhat different from those on black ones. The principal damage is done to fruiting canes, although new canes are attacked and occasionally killed during the first season of their growth. The foliage on affected canes wilts suddenly and becomes dry. The whole cane may be involved or only a portion of it. Often a single branch is killed, while the remainder of the cane continues alive and apparently normal. (See Plate VI.) In the majority of cases only a part of the cane dies. With black caps the disease frequently starts in the old stub left in pruning. From this point it gradually works downward, killing first the uppermost branch, then the next lower one, and so on until by the close of the berry harvest one-half or more of the cane may be dead. On black caps the disease also shows a tendency to work down one side of the cane, killing the bark and discoloring the wood on that side, while on the other side the bark remains green. This may occasionally happen with the red varieties, but as a rule they are attacked at some particular point on the cane. Here the bark is dead and the wood brown. For some time the injury extends only part way around the cane, and as long as there is a strip of green bark left connecting the parts above the point of attack with those below all goes well; but when the injury at length completely encircles the cane the leaves on that portion above the injury suddenly wilt and die. By the time this happens, the cane at the point of attack is dead throughout a section which is usually from two to four inches in length. Both above and below this dead section the cane itself may be normal, with nothing to indicate the cause of the sudden wilting of the leaves. However, a cane may bear several of these

dead sections of various sizes. If the point of attack is near the ground the whole cane dies; if higher up, only a part of it. When part of a cane dies while the remainder continues alive, the point of attack is to be sought at the boundary between the dead and living portions. Usually, the seat of the difficulty may be located by the color of the bark, which is somewhat different from that on the rest of the cane. For the most part it is lighter colored and smutty, with smoke-colored patches of exuded spores. In many cases numerous minute pimples, the pycnidia of the fungus, are visible. By cutting into the cane with a knife the matter may be decided at once. Where the cane is diseased the wood is strongly discolored. A marked characteristic of cane blight is the brittleness of the cane at the point of attack.

While it is common, both with black caps and red varieties, for the disease to be confined to one or more definite areas of infection on the cane, there are also many instances in which the disease pervades a large portion of the cane before death occurs. In such cases it is common for the affected wood to crack and the bark to peel off, particularly on the lower portion of the cane.

Fruiting canes affected with cane blight may die at any time. Almost as soon as the leaves unfold in the spring branches commence to die. As the season advances the disease increases in virulence and reaches the maximum during the ripening of the fruit. Canes loaded with ripening fruit suddenly wilt, either wholly or in part, and dry up. The disease does not spread from an initial center, but canes die here and there all through the plantation. Thrifty, well-cared-for plantations suffer as well as neglected ones.

So far as observed, only the canes are affected. The disease certainly does not attack the leaves, and the fact that new canes in badly diseased plantations make as good a growth as those in healthy plantations indicates that the roots are not affected.

In August and September the new canes of red raspberries often show bluish-black or brown areas from two to four inches in length and extending nearly or quite around the cane. These discolored areas are very conspicuous, and at one time were mistaken for the early stage of cane blight. Probably they have nothing to do with cane blight. The real cause of the discolora-

tion is given on page 128, where a full discussion of the subject will be found.

By careless persons cane blight is often mistaken for the work of the raspberry cane borer, *Oberea bimaculata;* but the absence of any insect burrow within the affected canes is conclusive proof that the trouble is not caused by a borer. Moreover, according to our observations, the raspberry cane borer is not common in New York. During the four years in which cane blight has been under investigation we have examined many plantations in various parts of the State and have only occasionally found the cane borer.

Cane blight has also been mistaken for the effect of drought and winter injury. While drought at fruiting time may aggravate cane blight it is certainly not the cause. Raspberries injured by drought dry up slowly and with considerable uniformity; whereas plants affected with cane blight die suddenly and a portion of the cane may be wholly dead while the remainder is as luxuriant as ever. In general, cane blight differs from winter injury in that canes injured by winter do not put out leaves on the injured portion, while plants attacked by cane blight may put out leaves normally and flourish until the fruit is nearly ripe, then suddenly die. However, it sometimes happens that canes severely attacked by cane blight during the first season of their growth are particularly susceptible to winter injury and do not put out leaves the following spring.

DAMAGE DONE AND VARIETIES AFFECTED.

In New York cane blight is so common that it is difficult to find a raspberry plantation wholly free from it, and yet it is probable that in a majority of the plantations the damage done by it is inappreciable. The loss of an entire crop because of cane blight is rare; but in many cases the loss has been as much as one-fourth to one-half of the crop, and occasionally as much as two-thirds. In the aggregate the loss from raspberry cane blight in New York must be enormous. Every season the Station receives numerous inquiries concerning the cause of cane blight and means of preventing its ravages. There is a widespread interest in the disease among growers of raspberries.

In general, it is more destructive in old plantations than in new ones, and as the age of a plantation increases the virulence of the disease increases. However, there are exceptions to this rule. At Marlboro, N. Y., a plantation of *Coutant No. 1* was so severely attacked in 1900 that the crop was reduced fully one-third. In 1901 and 1902 the loss from cane blight in this plantation was inconsiderable. At Charlotte, N. Y., in a plantation of Cuthbert, the loss, as estimated by the owner, was two-thirds of the crop in 1901 and only one-fourth in 1902. No doubt the virulence of the disease varies considerably from season to season owing to variation in weather conditions. Like most fungi, the fungus causing cane blight probably thrives best and spreads fastest in wet seasons, and yet losses from the disease may be heaviest in dry seasons. This comes about from the fact that canes become infected during the first season of their growth, but do not show the effects until the following season. It seems likely that the spread of the disease is most influenced by weather conditions during the period of infection and that after infection has once taken place the growth of the fungus within the cane is not materially affected by any weather condition except temperature. Furthermore, the effect of the disease is to restrict the circulation of sap in the canes. The death of the cane at the point of attack hinders the passage of water to the parts above and the leaves wilt from lack of it. It stands to reason that when the soil is full of water the leaves on affected canes would be able to hold out longer than in times of drought, when even unaffected plants have difficulty in getting water enough to maintain life. Since the requirements of the raspberry plant for water are greatest when the fruit is ripening, that is the time when the strangling effect of the disease may be expected to do the most damage.

Reasoning from what has just been said, it seems probable that cane blight will be most destructive when a warm, wet summer and autumn, suitable to infection, are followed by a warm spring and drought in July when the fruit is ripening; and, *vice versa,* the disease will be least destructive when a dry, cool summer and autumn are followed by a cool spring and wet July. If a part of the infection occurs in spring — a point not definitely

determined — the virulence of the disease would be increased by wet weather in April and May.

Raspberry plantations have to be renewed frequently. After three to five crops have been harvested it is a common practice to dig out the plants and start a new plantation. As a rule, old plantations are unproductive, but just why this is so is not clear. With black caps renewal is often necessitated by the increasing virulence of anthracnose (*Gloeosporium venetum*) and red rust (*Caeoma nitens*). Our observations lead us to believe that cane blight is often partly responsible for the early decline in productivity of both red and black raspberry plantations.

Nearly all varieties of raspberries are more or less affected by cane blight, but some are more susceptible to attack than others. Of the varieties extensively grown, Cuthbert probably suffers most of all. Marlboro, too, is much subject to the disease. Ohio, Gregg and Kansas are much affected, while Columbian, although not entirely exempt, is notably resistant to the disease. In the Station plantation the varieties Superlative, I. X. L. and Pride of Geneva have shown themselves particularly liable to attack. The wild red raspberry, *Rubus strigosus*, is often attacked.

Some of the canning factories complain that the supply of Cuthbert raspberries is not equal to the demand. Fruit growers explain this by saying that "the Cuthbert has such a tendency to dry up at fruiting time that it cannot be depended upon." Consequently, many who formerly grew Cuthbert are now planting Columbian, which is more productive but inferior in quality. We are of the opinion that this "tendency to dry up at fruiting time" is largely due to attacks of cane blight.

The cultivated dewberry is, perhaps, also affected by cane blight. At Portland, N. Y., in June, 1900, we saw canes of Lucretia dewberry wilting like raspberry canes attacked by cane blight, and at the base of the wilted portion a short section of cane was dead and covered with *Coniothyrium* as on raspberry canes. The resemblance to raspberry cane blight was so striking that we have not yet abandoned the idea that the raspberry *Coniothyrium* is parasitic on dewberry canes, although an inoc-

ulation experiment at Highland gave negative results. (See page 118.)

During the past four seasons the writers have had under observation a diseased dewberry plantation[1] at Highland, N. Y. Each season this plantation has been seriously injured by a disease, the exact nature of which we have been unable to determine. In 1900 the crop was a complete failure. The fruiting canes, wholly or in part, wilt and die as in raspberry cane blight; and the seat of the trouble seems to be located in a dead and discolored section of the cane. Such discolored sections showed no fungus on June 21, 1899, but on July 27, 1900, they were thickly covered with *Coniothyrium* and the wood at this point was brittle. *Coniothyrium* was also found on affected canes on June 27, 1901, and on June 4, 1902. Observations made in 1901 indicate that part of the trouble was due to winter injury and a part to some other cause. Suspicion points to *Coniothyrium* as this other cause.

One fruit grower claims to have seen a blackberry disease similar to the raspberry cane blight, but the writers have never seen anything to indicate that the disease attacks blackberries. In one instance a species of *Coniothyrium* was found on dead blackberry canes, but from the size of its spores and habit of growth on culture media it is evident that it was a different species than the raspberry *Coniothyrium*. (Compare Figs. 7 and 8, Plate X.) An attempt to inoculate blackberry canes with raspberry *Coniothyrium* failed. (See page 117.)

CAUSED BY A FUNGUS.

From the time of the first discovery of the disease at Coxsackie, N. Y., June 1, 1899, a Sphæropsideous fungus with small, roundish or elliptical brownish spores borne in pycnidia was suspected of being the cause. Every additional observation strengthened this suspicion until finally the evidence seemed so conclusive as scarcely to need the support of inoculation experiments. The fungus, a species of *Coniothyrium,* was constantly associated with the disease and nearly always in such a manner as to point plainly

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[1] This is the plantation mentioned in Bul. 167 of this Station, page 294.

to it as the cause. Whenever a portion of a cane was killed it was easy to locate the seat of the trouble in a short section of the cane at the base of the wilted portion. At this point the cane was dead and discolored, and microscopic examination invariably revealed the presence of the *Coniothyrium* in abundance. By the time the leaves were fully wilted, and oftentimes earlier, the *Coniothyrium* could be depended upon to show its pycnidia filled with multitudes of ripe spores. In many cases the spores were expelled from the pycnidia and formed brownish or slate-colored patches on the dead bark. Sometimes large portions of the dead and dying canes would be smutty with masses of the exuded spores.

While divers other fungi were frequently associated with the *Coniothyrium* on diseased canes, no fungus except *Coniothyrium* was constantly present. Not only was *Coniothyrium* always found on diseased canes, but it was always absent from perfectly healthy ones; and whenever the pycnidia of *Coniothyrium* were found the bark was dead and the wood underneath discolored.

IDENTITY OF THE FUNGUS.

In our first published account[2] of cane blight the causal fungus was referred to the genus *Phoma*. This was manifestly an error inasmuch as the spores have a decidedly brownish tinge. The genera *Phoma* and *Coniothyrium* differ only in the color of the spores, the former having hyaline spores and the latter colored spores. Seen singly, the spores of the cane blight fungus have a slightly brownish tinge and in mass the brown color becomes pronounced. It is plain that the fungus belongs to the genus *Coniothyrium* rather than to *Phoma*. This correction has already been made in Bulletin 191 of this Station, page 330.

Although the writers are not yet prepared to make a positive statement as to the specific name of the fungus it seems probable that it is *Coniothyrium fuckelii* Sacc. According to Saccardo,[3] *C. fuckelii* occurs on the bark of dead and dying branches of *Rubus, Ampelopsis, Tecoma, Rosa, Robinia, Berberis* and *Helianthemum,* and on the leaves of *Citrus*. On these different hosts the

[2]Bul. 167 of this Station, pp. 305–307.
[3]Saccardo, P. A. Syll. Fung. 3:306.

size and shape of the spores vary somewhat. On *Rubus,* the spores are said to be globose with a diameter of 3 to 4 μ. The spores of the cane blight *Coniothyrium* have, approximately, these dimensions and their usual form may be properly described as globose, although many of the spores might be called ellipsoidal. (Plate X, Fig. 7.)

We have not had the opportunity of examining authentic specimens of *C. fuckelii* on *Rubus* or, in fact, on any of its hosts except *Tecoma radicans,* the trumpet creeper. Through the kindness of Dr. W. G. Farlow we have been able to examine a fragment of a specimen on *T. radicans* collected by Saccardo. In this specimen the spores are considerably longer than broad and nearly hyaline. They are decidedly different from the spores of the cane blight *Coniothyrium;* but *C. fuckelii,* as described, is a variable species and it may be that our fungus belongs here notwithstanding.

INOCULATION EXPERIMENTS.

General statement.— Inoculation experiments with pure cultures have been made on new canes and fruiting canes of both red and black raspberries and the new canes of dewberry and blackberry. The inoculation has been done in divers ways with cultures from three different sources. These experiments will now be described in detail and in chronological order.

Experiment No. 1.— Date of inoculation, July 18, 1900. Five new canes of red raspberry (variety, Pride of Geneva) were inoculated in the following manner: About one foot below the tip of the cane the bark was slightly abraded with a flamed scalpel. On the wound thus made there was placed a bit of the *Coniothyrium* from a pure culture originally isolated in 1899. The culture used for inoculation was a mixture of two cultures—one forty-six days old and containing multitudes of spores, and the other six days old, without spores. The final operation consisted in covering the wound with grafting wax which was wound closely about the cane in such manner as to exclude the air and foreign organisms. (See Plate VII.)

On September 18, two months after inoculation, it was found that on all five canes the leaves about the point of inoculation

were either wilted or dried up. For a short distance, both above and below the wax, the bark was dead and brown and the wood discolored. In every case the dead bark in the vicinity of the wax (both above and below it) was covered with *Coniothyrium* pycnidia containing mature spores. One cane, broken accidentally, was very brittle at the point of inoculation as is the case with affected canes in nature. Although this experiment had no check the results indicated that the *Coniothyrium* is parasitic.

Experiment No. 2.— Date of inoculation, July 18, 1900. Four new unbranched canes of black raspberry (variety, Mohler) inoculated, as in Experiment No. 1, by abrading the bark, applying fungus and winding with grafting wax. Two other canes of the same variety but considerably branched were inoculated in a freshly cut stub, such as is commonly left in "heading back" the canes. The stub was covered with grafting wax. The fungus culture used was the same as that used in Experiment No. 1. There were no checks.

On October 1, 1900, two of the unbranched canes were dead and the other two had prominent scars at the point of inoculation. Whether these two canes were killed by *Coniothyrium* is uncertain. One showed an abundance of *Coniothyrium,* both above and below the wax, but on the other there was no sign of *Coniothyrium.* At this date the two branched canes inoculated in the stub were beginning to show the effects of inoculation. On one, the uppermost branch was already involved.

The last observations were made July 8, 1901, at which date one of the two remaining unbranched canes was nearly dead while the other was alive and apparently little harmed by inoculation. The dying cane showed an abundance of *Coniothyrium* pycnidia scattered along one side for a distance of several inches below the point of inoculation. One of the two branched canes inoculated in the stub was dying in the upper portion although it bore a fair crop of fruit. Two of the upper branches were dead. The fungus had worked down the cane about five inches from the point of inoculation and pycnidia were plentiful. The condition of the other branched cane was unchanged since the preceding October. It was uninjured.

In this experiment the symptoms of the inoculated plants were like those of naturally infected plants, but the progress of the disease was slow. It may be that Mohler is more resistant than some other varieties.

Experiment No. 3.— Date of inoculation, June 8, 1901. Five new canes of red raspberry (variety, Pride of Geneva) were inoculated with a month-old culture, the source of which was isolated May 1, 1901, from black raspberry. The canes, which were 24 to 30 inches high, were inoculated 6 to 8 inches below the tip by abrading the bark, applying a bit of fungus and winding the whole with grafting wax as in Experiment No. 1. Five check canes were abraded and wound with wax in the same manner but without application of the fungus.

On August 28 four of the inoculated canes showed more or less discoloration around the wax while the remaining cane seemed normal. None of these canes showed any wilted foliage. At the same date three of the checks were free from all signs of infection, but the other two had pronounced discoloration of the bark around the wax as on the inoculated canes. Thinking that the checks had become naturally infected by the fungus, which was very common among the plants of this variety, the experiment was abandoned and no further observations were made. Consequently, the ultimate results are not known and the experiment teaches nothing except that variable results from inoculation are to be expected. In 1901 new canes of this variety, inoculated in the same manner, were dead within two months after inoculation. (See Experiment No. 1, page 115.)

Experiment No. 4.— Date of inoculation, June 8, 1901. Five new canes of blackberry (variety, Taylor) were inoculated in the same manner and with the same culture as that used on red raspberry in Experiment No. 3. The canes were about 30 inches high and inoculated 6 to 8 inches below the tip. There were five checks.

On August 28 there was no discoloration of the bark around the wax and no other evidence that the inoculation had had any effect whatever.

Experiment No. 5.— Date of inoculation, June 13, 1901. Ten new canes of Lucretia dewberry were inoculated with a fourteen-day-old culture descended from the culture used in Experiment No. 3. Six to eight inches below the tip the canes were slightly abraded, a drop of water placed on the wound, then the fungus applied and the cane wound with grafting wax in the customary manner. There were ten checks.

On September 12, 1901, there were no signs that inoculation had had any effect. Final observations were made on May 8, 1902, at which time all ten checks and nine of the inoculated canes were found to have been winter killed, with no sign of *Coniothyrium* about them. However, the tenth inoculated cane, although alive both above and below the wax, was partially dead at the point of inoculation and covered with *Coniothyrium* pycnidia underneath the wax. It appeared as if infection may have occurred on this cane.

Experiment No. 6.— Date of inoculation, June 14, 1901. Ten new canes of red raspberry (variety, *Coutant No. 1*) were inoculated 6 to 8 inches below the tip with the same culture used in Experiment No. 5. The fungus was producing spores abundantly. The method of inoculation was by abrasion of the bark, application of a drop of water and a bit of fungus and the whole covered with grafting wax. The canes were 26 to 30 inches high. There were ten checks.

On September 2, 1901, all of the inoculated canes (except one broken by the wind July 10) and all of the checks were alive and apparently little worse for inoculation. There was only a little discoloration of the bark around the wax but the canes were somewhat enlarged and cankers were forming.

On May 7, 1902, only three of the inoculated canes were alive above the wax and these were badly cankered. Four had broken off at the point of inoculation and the tops had disappeared. One other cane was all dead above the wax, with *Coniothyrium* pycnidia, and one had been broken, accidentially, eight inches below the wax. The tenth cane had been broken by wind the previous July. At this date nine of the checks were alive and apparently normal except for being somewhat

enlarged under the wax and flattened on the side abraded. The remaining cane was all dead above the wax with a pronounced enlargement and canker at the wax.

In a hasty examination made May 29, 1902, all of the inoculated canes were found to be dead above the wax, while at least eight of the checks were still alive.

Final observations made July 25, 1902, showed the condition of the checks to be as follows: 4 alive throughout, 4 dead throughout, 1 dying and 1 dead above the wax.

The results of this experiment are unsatisfactory and difficult to interpret. The fact that the inoculated canes all died before June 1, while at least eight of the checks were yet alive, indicates that inoculation had some effect. The tendency of the inoculated canes to break at the point of inoculation is to be ascribed to brittleness induced by the attack of the fungus, as is conspicuously the case with plants naturally infected.

Experiment No. 7.— Date of inoculation, June 14, 1901. Ten new canes of red raspberry (variety, *Coutant No. 1*) were inoculated near the base with the same culture used in Experiments 5 and 6. In all preceding experiments the inoculations had been made well up toward the top of the canes. It was now desired to learn what would happen if canes were inoculated near the base. Accordingly, in this experiment the bark four or five inches above the surface of the soil was abraded, then a drop of water and bit of fungus applied and the cane wound with grafting wax as usual. There were ten checks.

Within a month after inoculation both the inoculated canes and checks began to show a bluish-black discoloration of the bark above and below the wax. By September 2 all of the inoculated canes were much discolored around the wax. They were also considerably enlarged and badly scarred on the inoculated side. The checks were in practically the same condition.

The following spring, on May 7, 1902, the checks were all still alive and standing, while among the inoculated canes only five were alive, and of these two were broken at the base. The other five had been broken in the process of laying the canes down for winter.

Between May 7 and July 25, 1902, three check canes died and one was lost, leaving only six alive at the latter date. During the same period the condition of the five living inoculated canes remained unchanged.

Here, as in Experiment 6, the brittleness of the inoculated canes at the point of inoculation is to be regarded as evidence that infection occurred. It is not strange that the checks became discolored around the wax. At the time of making the inoculations there was considerable dirt on the canes near the ground. The canes being thickly beset with prickles it was next to impossible to wash them with disinfecting solutions, and it was not attempted. It is probable that spores of *Sphærella rubina* (see page 129) and perhaps also those of *Coniothyrium* got into the wounds and caused the discoloration of the check canes. According to the writer's observations, grafting wax wound about the canes, as in these experiments, causes, at most, only a slight discoloration of the bark and usually no discoloration whatever.

Experiment No. 8.— Date of inoculation, May 17, 1902. This experiment was designed to furnish information on the following points: (1) Is it possible to produce infection by inoculation during the spring of the second season's growth; that is, on fruiting canes? (2) Can infection be brought about more readily by making a puncture passing through the pith than by simply abrading the bark as in all previous experiments? (3) Is it necessary to use grafting wax to cover the wounds?

Twenty-five fruiting canes of the variety Cuthbert were selected for the experiment. At the point selected for inoculation, about one foot below the tip, each cane was first thoroughly washed with a 1-1000 solution of corrosive sublimate to remove any fungus spores lurking there.

Five canes were abraded with a flamed scalpel, a drop of distilled water and a bit of fungus applied to the wound and the cane wound with grafting wax. Five checks were treated in the same way except that the fungus was omitted.

Five other canes were bored through with a sterilized awl, a bit of fungus crowded into the hole, a drop of distilled water

applied and the cane wound with grafting wax. There were also five checks to this part of the experiment.

Finally, five other canes were inoculated by puncturing with an awl and applying fungus and distilled water, but *the canes were not wound with wax.*

The fungus used throughout this experiment consisted of a mixture of two cultures, one of which was twelve days old and the other fifty days. It was descended from the fungus used in Experiments 3-7 inclusive, and was originally isolated May 1, 1901.

On August 8, 1902, all 25 canes in the experiment were cut and each one carefully examined. Of the five canes inoculated by abrasion four were dead from the wax up and covered with *Coniothyrium* pycnidia around the wax, both above and below it. The bark was dead and the wood discolored from two to three inches below the point of inoculation. The fifth cane was alive, but at the point of inoculation the wood was discolored and bore *Coniothyrium* pycnidia. Of the five checks belonging to this part of the experiment four were alive and green with no discoloration of the bark or wood anywhere, and with no sign of *Coniothyrium.* The remaining check was still alive, but had a pronounced discoloration of the bark and wood each side of the wax and an abundance of *Coniothyrium* was present. In some way it had become infected.

Of the five canes inoculated in a puncture covered with wax every one showed an abundance of *Coniothyrium* pycnidia in the vicinity of the wax. Four were dead and broken at the point of inoculation, while the fifth one, although still alive, had the bark dead and wood discolored one-half way around the cane for a distance of four inches above and two inches below the wax and thickly covered with *Coniothyrium* pycnidia. This cane was considerably larger than the other four, which probably explains its greater resistance to the disease. The five checks belonging to this part of the experiment were all alive and green with no discoloration of the bark or wood around the puncture in any case and none of the canes were broken.

Of the five canes inoculated in punctures, which were *not* covered with wax, every one showed an abundance of *Coniothy-*

rium around the point of inoculation. Two were still living, but the bark and wood on both sides of the wax was discolored and one cane was partly broken off. The other three canes were dead from a point three inches below the wax to the tip and two of them were broken at the point of inoculation. This experiment was highly satisfactory, and, of itself, proves beyond doubt that the *Coniothyrium* is capable of killing raspberry canes.

Experiment No. 9.— Date of inoculation, June 3, 1902. Five fruiting canes of red raspberry (variety, Cuthbert) were inoculated at a point 12 to 18 inches below the tip by first washing the cane with a 1-1000 corrosive sublimate solution, then boring clear through the cane with a sterilized awl, crowding a bit of fungus into the hole, applying a drop of distilled water and finally winding the cane with grafting wax in the customary manner. The culture used was 19 days old and originally isolated May 15, 1902; hence it was different from that used in any of the preceding experiments. Five check canes were treated in identically the same manner except for the omission of the fungus.

On August 8, a little over two months after inoculation, all ten canes were cut and examined. The five inoculated canes were all dead from a point two to four inches below the wax to the tip of the cane. For a short distance on either side of the wax the dead bark was thickly covered with *Coniothyrium* pycnidia in every case. Three of the canes were broken at the point of inoculation.

At the same time the five checks were alive and green throughout, none broken and none showing discoloration of the bark or wood around the puncture.

Experiment No. 10.— Date of inoculation, June 5, 1902. Five fruiting canes of black raspberry (variety, Bishop) inoculated 10 to 12 inches below the tip by puncturing the cane with a sterilized awl, inserting a bit of fungus in the hole and winding the cane with grafting wax. The culture was 21 days old and of the same strain as that used in Experiment No. 9. Three checks were made.

The eight canes were cut and examined August 9, 1902. Of the five inoculated canes three were dead from the wax up, and showed an abundance of *Coniothyrium* pycnidia on either side of the wax. The other two inoculated canes were still alive at the top, but on both there was much discoloration of bark and wood, and plenty of *Coniothyrium* pycnidia in the vicinity of the wax. On one, this discoloration extended half way around the cane and to a distance of three inches below the wax, while on the other it extended two inches above and one inch below. In both cases it was plain that the fungus had attacked the canes.

On the same date all three checks were alive and green to the top. On two of them the bark was green under the wax and not the least bit discolored, but the third showed a slight discoloration in the immediate vicinity of the puncture. However, no *Coniothyrium* could be found.

Experiment No. 11.— Date of inoculation, June 6, 1902. Ten new canes of red raspberry (variety, Cuthbert) 20 to 30 inches high were inoculated about 8 inches below the tip as follows: The cane was first washed with a 1-1000 corrosive sublimate solution, then bored through with a sterilized platinum needle, a bit of fungus crowded into the hole thus made, a drop of distilled water applied and the whole wound with grafting wax. The fungus used was of the same strain as that used in Experiments 9 and 10. Five checks were made.

On August 8 five of the inoculated canes were all dead above the wax and about one inch below it. The tops of two of these were lost, but the stubs showed an abundance of *Coniothyrium* pycnidia; and the other three were covered with *Coniothyriu* for an inch above and an inch below the wax. The remaining five inoculated canes were still alive at the top, but all had cankers at the point of inoculation, three of them being bad and one showing *Coniothyrium* pycnidia under the wax. These five canes were considerably enlarged and the bark and wood discolored at the point of inoculation. Thus, on six of the inoculated canes there was undoubted *Coniothyrium* infection, and on the other four there was some evidence of it, although no

Coniothyrium pycnidia could be detected. These ten canes are shown in Plate VIII.

On the same date one of the check canes was found to have been killed by a borer, but the other four were alive clear to the top. The only thing abnormal about them was a slight discoloration of the outer layer of bark under the wax. In no case was the wood discolored and no *Coniothyrium* was found.

Remarks.—Experiment No. 5 was conducted at Highland, N. Y.; Nos. 6 and 7 at Milton, N. Y.; and all of the others on the Station farm at Geneva. Nos. 8, 9 and 11 are the most trustworthy because they were conducted in a small, isolated plantation which was, apparently, entirely unaffected by cane blight. Also, the inoculations were made with especial care.

Interpretation of the results.— These experiments prove conclusively that the raspberry *Coniothyrium* is parasitic on raspberry canes (both black and red varieties) and the cause of cane blight. It will attack new canes as well as fruiting canes, but seems somewhat more active on the latter. Although the experiments on blackberry and dewberry gave negative results it should not be considered proven that the fungus is incapable of attacking these plants, for the reason that there was but a single experiment in each case.

Both old and new canes may be expected to succumb to the disease within two months after inoculation, and *Coniothyrium* pycnidia with mature spores may be produced in abundance during the same period.

TIME AND MANNER OF NATURAL INFECTION.

Although new canes are rarely killed by cane blight during the first season of their growth this does occasionally happen, and there is also other evidence to show that infection occurs on new canes. On August 28, 1901, the writers observed a stool of black raspberry in which several of the new canes were wilting and dying. Upon examination it was found that at the very base of the dying canes the bark and wood were dead and brown and bearing *Coniothyrium* pycnidia. This occurred on the Station grounds at Geneva and appeared to be a case in which cane blight

was killing new canes. On September 19, 1900, new canes of black raspberry which had been " headed back " some time during the summer showed mature *Coniothyrium* pycnidia on the dead stubs.

At one time it was thought that the early stage of cane blight had been discovered in the bluish-black areas found on new canes of red raspberries in autumn. It is now known that these discolored areas are due to another cause. (See page 128.)

In spring, as the leaves are unfolding, one may occasionally find canes already affected with cane blight in a stage so far advanced as to make it certain that they were infected the previous season. For example, on May 5, 1902, a vigorous cane of the variety Conrath was found to be affected with cane blight at a point about a foot below the tip. Here the bark and wood were discolored over an area three-fourths of an inch long and one-four inch wide and there were numerous pycnidia of *Coniothyrium* filled with ripe spores. This cane must have been infected the previous season.

On May 8, 1902, a plantation of the variety Kansas was examined at Poughkeepsie. It was observed that some canes were either dead or putting out leaves very sparingly, indicating that something was wrong. In the majority of such cases it was possible to trace the cause of the trouble to a dead area somewhere on the cane and this dead area showed many pycnidia of *Coniothyrium*. These infections could not possibly have occurred in the spring of 1902; they must have occurred in 1901 on the new canes.

In several other instances well advanced cases of infection, with mature spores of *Coniothyrium* present, have been observed during the first week in May. In 1900 a plantation in Ulster County was quite seriously affected as early as May 24. There can be no doubt that part of the infection, at least, occurs on new canes.

On the other hand, there are some reasons for believing that infection may also occur on the fruiting canes in the spring. In general, it is difficult to locate affected canes before the appearance of the leaves. On May 1 it may be difficult to find *Coniothyrium* pycnidia in plantations in which, by July 1, the fungus occurs abundantly on almost every cane. If infection occurs only

on new canes it seems scarcely possible that the canes could be so generally infected and not show it in the early spring. Inoculation experiments Nos. 8 and 9 (pages 120-122) show that the fungus grows readily in fruiting canes and kills them when artificially inoculated as late as June 3 and under conditions such as might easily occur in nature; that is, in uncovered wounds. However, the results of the spraying experiment at Charlotte (page 132) tend to show that infection does *not* occur on fruiting canes. This question must still be considered an open one.

As to the manner of natural infection it may be said that it often occurs in wounds of various kinds. A careful examination of an affected plantation will reveal the fact that in a large percentage of cases there is some break in the epidermis of the cane at the point of attack. With black caps, the disease very frequently starts in the dead stubs which result from the "heading back" of the young canes. As the disease works downward the lateral branches are killed one after another. Some fruit growers have attributed this form of cane blight to a green bee which is often found burrowing in the dead stubs during May and June. Frequently, the dead stubs have a hole in the top and upon splitting open such canes the burrow is found to extend downward from one to four inches and contain one or more green bees about one-fourth of an inch in length. This insect is the carpenter bee, *Ceratina dupla,*[4] and is harmless, inasmuch as it bores only in dead wood. It is found, also, in the stubs of blackberry canes.

Cane blight often starts in wounds made by the "heading back" of new canes, by the removal of branches, by the rubbing of canes against each other or against supporting wires, and particularly in crotches where the branches are more or less split apart and in wounds made by the snowy tree cricket, *Oecanthus niveus,* during oviposition. The snowy tree cricket forces its ovipositor into the cane in such a manner as to kill the tissues and cause the cane to split. The wounds thus made furnish a lodging place for *Coniothyrium* spores and also for water necessary to the germination of the spores, making the condition exceptionally favorable for infection. That infection does actually oc-

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[4] Determined by V. H. Lowe.

cur in snowy tree cricket wounds is shown by the large number of instances in which the cane is covered with *Coniothyrium* pycnidia in the vicinity of the wounds, usually just below them. The well known tendency of cricket-injured canes to break at the point of attack is probably due, in part, to brittleness induced by the *Coniothyrium.* It appears that the injury done by the snowy tree cricket is often much aggravated by the cane blight fungus.

In some cases *Coniothyrium* takes possession of the discolored areas caused by *Sphaerella rubina,* but this is not the rule.

While *Coniothyrium* often takes advantage of wounds as described above it is by no means certain that it should be classed as a wound parasite. Although not definitely proven by inoculation experiments there is considerable evidence that the fungus is capable of penetrating the unbroken epidermis of raspberry canes. It is often found attacking uninjured canes where the bark is smooth and the epidermis seemingly intact except as it is rupteured by the *Coniothyrium* pycnidia themselves.

MODE OF DISSEMINATION.

For the successful application of preventive measures an accurate knowledge of the mode of dissemination of the fungus is essential. It is in the highest degree important to know the means by which the fungus is spread from plant to plant, from one plantation to another and into new localities. It must be admitted that our knowledge of this subject is very incomplete. However, some things are known.

There can be no doubt that the disease is widely disseminated by means of infested nursery stock. Plants taken from badly diseased plantations are fairly certain to carry the disease with them, on the piece of attached cane or on the dirt about the roots. It is not necessary to assume that every plant is affected at the beginning. If a few plants here and there carry the disease with them it gradually spreads to other plants in the plantation in various ways.

Wind and dashing rains drive the spores from cane to cane, and by the washing of the soil, spores may be carried to other parts of the plantation or even to neighboring plantations. Birds and insects probably carry the spores to a limited extent. The

disease must be spread by pickers while gathering the fruit; also in pruning and in cutting out the old canes; and particularly in the process of laying down and covering the canes with soil to protect them from winter injury. Cultivation, too, tends to spread the disease.

The fungus can live on dead and decaying raspberry canes, and fragments of diseased canes lying on the ground are no doubt a prolific source of infection. How long the fungus can live on decaying material is not known. Another important point on which there is as yet very little accurate information is the relation of the fungus to plants other than the raspberry. If it lives on a variety of other woody plants, as suggested by Saccardo (see page 114), such plants must serve to assist its dissemination.

All of the evidence at hand tends to show that the fungus does not travel any considerable distance except on infested plants.

RELATION OF CANE BLIGHT TO THE DISCOLORED AREAS ON RED RASPBERRY CANES.

During August and September the new canes of red raspberries often show brown or bluish-black areas one to four inches long and extending one-half to two-thirds or more of the way around the cane. (See Plate IX, Fig. 1.) These discolored areas are conspicuous and sharply defined. The discoloration is only in the bark and never extends to the sapwood. The cane is but slightly if at all constricted and, until the following spring, there is usually no evidence of any fungus in the fruiting stage. A single cane may bear from one to several such areas which may be located anywhere on the cane, but occur most commonly on the lower portion. These discolored areas are exceedingly common on many varieties of red raspberries (*Rubus strigosus* and *R. idæus*) and have been found also on the purple variety Shaffer (*R. neglectus*), but have never been observed on any of the black varieties (*R. occidentalis*). The health of the affected canes does not seem to be impaired.

At one time this discoloration was believed to be the early stage of cane blight,[5] but it has now been determined that they are due to an entirely different cause.

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5 See Bul. 191 of this Station, page 350.

During the winter the dark discoloration gradually changes to a light gray and the areas become indefinite in outline and more difficult to locate. (Plate IX, Figs. 2-4.) In April they are found to be thickly studded with small black perithecia, the numerous asci of which each contain eight two-celled hyaline spores disposed in uniseriate or subbiseriate fashion. (Plates IX and X.) By May 1 the entire lower portion of many canes is light gray in color and thickly covered with the perithecia. Still there is no discoloration of the wood underneath and no other indication of injury to the canes.

Some canes affected in this way were marked and watched for about three months to ascertain if they became affected with cane blight later. On May 2, 1902, ten affected canes of the variety Carleton were selected and labeled. Care was taken to select canes on which the affected areas were well defined. From each, a bit of bark was taken and examined with the microscope to make sure that the fungus present on the gray areas (formerly bluish-black) was the pyrenomycete above mentioned. On August 7, 1902, the ten canes were cut and carefully examined. All were either dead or dying, but in every case the cause was traced to a *Coniothyrium* infection at some other point on the cane, usually higher up. In two cases the *Coniothyrium* had made its attack just above the gray area and here the *Coniothyrium* pycnidia were intermingled with the perithecia of the pyrenomycete. It was plain that the gray areas were not the seat of the trouble and that the pyrenomycete was not succeeded by *Coniothyrium*. This view is supported by numerous other observations and we think that it may be accepted as an established fact that the discolored areas, which are bluish-black or brown on new canes and light gray and inhabited by the pyrenomycete the following spring, do not represent the early stage of cane blight; also, that this pyrenomycete and *Coniothyrium* are two entirely distinct fungi. In April and May it is sometimes difficult to distinguish, without microscopic examination, *Coniothyrium* infections from the gray areas inhabited by the pyrenomycete. The color of the bark is similar, but if the *Coniothyrium* has expelled its spores it may be recognized by the smoke-colored smuttiness

at the point of attack. In general, the matter may be decided at once by cutting into the cane with a knife. If the wood is discolored it is almost certain to be *Coniothyrium*. If the wood is not discolored it is most likely to be the pyrenomycete, although *Coniothyrium* will occasionally occur sparingly where there is scarcely any discoloration of the wood. To the unaided eye the *Coniothyrium* pycnidia are practically indistinguishable from the perithecia of the pyrenomycete.

The pyrenomycete under discussion appears to be *Sphærella rubina* Pk. described by Peck in the Forty-eighth Annual Report of the New York State Museum, Part I, page 114. The description reads as follows:

"*Sphærella rubina* n. sp. Perithecia minute, .007 to .009 in. broad, commonly gregarious, sometimes forming extended patches, submembraneous, obscurely papillate, pertuse, subglobose or depressed, at first covered by the epidermis, becoming superficial when the epidermis falls away, black; asci cylindrical, subsessile, .003 to .0035 in. long, .00045 to .0005 broad; spores uniseriate or subbiseriate, oblong, obtuse, uniseptate, generally constricted in the middle, hyaline, .0006 in. long, .00024 to .0003 broad, the upper cell often a little larger than the lower.

"Stems of cultivated raspberries. Menands. April and May.

"This species is injurious to the plants it attacks. The affected plants either die from the disease or are so weakened by it that they are winter-killed wholly or in part. Generally the epidermis is whitened over the patches of the fungus, but sometimes brown spots indicate the presence and location of the fungus. The mycelium consists of brown septate filaments. From *Didymella applanata*, which this fungus resembles in some respects, it is separated by the absence of paraphyses."

With the writers it is an open question whether paraphyses are present or absent, and we must take exception to the statement that the *Sphærella* is injurious to the canes on which it occurs. We have seen good crops of fruit produced in plantations in which almost every cane bore more or less of the *Sphærella* the preceding spring. Its seeming injurious effect is due to the fact that it occurs most abundantly on red varieties which are especially liable to winter injury and to attack by cane blight.

Under the microscope, the perithecia quite generally show a conspicuous light-colored, circular area at the center, as shown in Fig. 1, Plate X. This is the ostiolum. When the perithecia are crushed under a cover glass the asci come out clinging together at their bases. They have the shape of a banana and in clusters resemble the banana clusters of six to twelve fruits each offered for sale by fruit venders. They cling together tenaciously. Mature spores may be found in abundance by May 1 and at Milton, N. Y., we have found them as early as April 8; but, in general, during the month of April the perithecia contain asci which are mostly without spores. According to our measurements the asci are 60 to 70 μ long by $10\frac{1}{2}$ μ wide, and the spores **14 to 19** μ long by $5\frac{1}{4}$ to $8\frac{1}{2}$ μ wide. (For the superior cell.)

Several unsuccessful attempts have been made to obtain pure cultures of *Sphærella* by the dilution method with potato agar. Often there is associated with the *Sphærella,* a species of *Phoma* having small, oblong, hyaline spores. (Plate X, Fig. 6.) The *Phoma* and *Sphærella* are so frequently found together as to arouse the suspicion that the former may be an immature form of the latter. Pure cultures of this *Phoma* have been obtained and grown for several months on sterilized bean stems, raspberry canes and plugs of sugar beet, but no indication of *Sphærella* perithecia appeared in any of the cultures.

In 1901 the Station raspberry plantation, containing many varieties, was carefully watched to ascertain the date of the first appearance of the discolored areas on the new canes. They were first observed July 8 on the variety Pride of Geneva. In 1902 a plantation of the variety *Coutant No. 1,* at Marlboro, was watched for the same purpose. The discolorations were plentiful on July 22, after two days of almost continuous rain. A few were observed some days earlier, but on the date mentioned there was a general outbreak.

The writers suspect that the discolored areas discussed above and attributed to *Sphærella rubina* are identical with those described in 1891 by Miss Detmers in Ohio Experiment Station Bulletin, Vol. IV, No. 6, p. 128. At any rate her description answers very well for the trouble under discussion except for the leaf symptoms, which may have been due to other causes.

Dr. Burrill, to whom Miss Detmers referred the matter, pronounced it a bacterial disease identical with pear blight. In the literature of raspberry disease this article of Miss Detmers has been frequently cited, but so far as we know there is no other published evidence that the raspberry is subject to a bacterial disease. Card's[6] illustration of a raspberry cane affected with the supposed bacterial disease is a good illustration of the discolored areas which we believe to be due to *Sphærella rubina.*

It appears that raspberry canes in England are affected by a disease having similar symptoms. In the *Gardener's Chronicle,*[7] an English periodical, an inquiry is answered concerning a raspberry disease producing black patches on the canes. Mr. George Massee is quoted as authority for the statement that the discolored patches are caused by a species of *Dothidea,* probably *D. rosæ.*

SPRAYING EXPERIMENT AT CHARLOTTE.

In the season of 1901 a Cuthbert raspberry plantation belonging to Dobson Bros., of Charlotte, N. Y., was injured by cane blight to the extent of two-thirds of the crop, as estimated by the owners. The writers first became acquainted with the plantation on May 21, 1902. At that date it appeared to be in good condition; the canes were large and strong and the foliage good. The average observer would have said that there was an excellent prospect for a heavy crop; but close examination showed that many of the canes were already affected with cane blight and showing *Coniothyrium* pycnidia. In fact, canes here and there were already partially dead with the disease, and it seemed likely that there might be a severe outbreak of it a little later.

Arrangements were at once made to conduct a spraying experiment in this plantation to ascertain if the crop of the present season could be saved in that way. Of course it was not expected that the disease could be checked in canes already infected; but it was hoped that the fruiting canes might be protected against further infection.

The plantation contained about $1\frac{1}{8}$ acres, consisting of 44 rows 185 feet long. Twenty-four rows were sprayed and the remaining

[6] Card, F. W. Bush Fruits. Fig. 46. The Mac Millan Co. New York. 1898.

[7] *Gardeners' Chronicle,* Third Series, 11: 631. 1892.

20 left unsprayed for checks. Throughout the plantation strips of four sprayed rows alternated with strips of four unsprayed rows.

Bordeaux mixture of the 1-to-10 formula was applied thoroughly three times, namely, on May 26, June 4 and June 16. The spraying outfit used is shown in Plate XI. It was operated by two men and a boy. At each spraying about 100 gallons of bordeaux mixture were used and the time consumed in making and applying it was 5½ hours. Since the area sprayed was a trifle less than two-thirds of an acre, the bordeaux was applied at the rate of about 150 gallons per acre. Both the canes and the foliage were sprayed thoroughly, special attention being given to the canes.

From observations made on August 2 it is plain that spraying did not check the disease. Apparently, there were as many dead canes in the sprayed rows as there were in the unsprayed ones. In one sprayed row, selected at random, the dead canes were counted and found to number 239, while in the adjacent unsprayed row there were but 172. This difference was probably accidental, but certainly there was nothing to indicate any benefit from spraying.

The yield of fruit, likewise, was disappointing. The fruit was gathered under the supervision of Dobson Bros., who also kept the record of the yield. Between July 14 and August 6 the plantation was picked over eleven times. The total yield of the twenty-four sprayed rows was 4,446 pints or 185¼ pints per row. The twenty unsprayed rows gave a total yield of 4,070 pints or 203½ pints per row. Thus the unsprayed rows outyielded the sprayed rows by 18¼ pints per row or about 725 pints per acre.

As nearly as can be estimated, the loss from cane blight was 25 per ct. of the crop. Spraying, instead of reducing the amount of the loss, apparently increased it. It seems unlikely that this difference in yield was accidental. The plantation was unusually uniform throughout and such inequalities as existed were mostly equalized by the alternation of sprayed with unsprayed rows. Assuming that no error was made in keeping the record the only way in which the difference could be accounted for is to suppose that the blossoms were injured by the spray. At the time of the

last spraying, June 16, a good many blossoms were open. The foliage was not injured by spraying.

Since at least a part of the infection occurs on new canes the best results from spraying are to be expected where the spraying is begun on the new canes and continued on the fruiting canes the following spring. Experiments along this line are now in progress in the Dobson plantation. After the fruit was gathered the sprayed rows were given three more applications of bordeaux mixture, and next spring they will be sprayed three or four times more before the fruit is large enough to be discolored by the bordeaux.

PREVENTIVE MEASURES.

Start with healthy plants.— Judging from what is now known concerning raspberry cane blight it appears that the first and most important consideration is to secure healthy plants with which to start the plantation. Unfortunately, there is no way of accurately determining, by an examination of the plants themselves, whether or not they are infested by the disease. Unless the planter can personally examine the plantation from which the plants are to be taken (and this must be done the summer before the plants are needed) he must rely on the honesty of the nurseryman or other person who grows the plants. This matter is greatly complicated by two things: (1) Cane blight is widely distributed — the majority of the raspberry plantations in this State contain more or less of it; (2) the difficulty of correct diagnosis. As yet, very few fruit growers are sufficiently acquainted with cane blight to be able to say positively whether it is or is not in their plantations. However, one thoroughly familiar with the symptoms can usually make a correct diagnosis without resorting to the use of a compound microscope.

By taking reasonable precautions the planter can usually make sure that his plants do not come from badly diseased plantations, at least.

Avoid planting on the site of diseased plantations.— It is scarcely necessary to say that it is unwise to set a new plantation on land where raspberries have been recently affected by cane blight. Probably the fungus survives for a time on and in the

soil, but how long is not known. After a severe attack of cane blight the land should not be replanted with raspberries for at least three years.

Removal of old canes.— Immediately after the fruit is gathered, cut out and burn the old canes. The old canes harbor the fungus. They are covered with multitudes of *Coniothyrium* spores and if allowed to remain standing in the plantation until winter they must be an important source of infection to the new canes. It is too much to expect that by prompt removal of the old canes cane blight can be entirely controlled, because under favorable weather conditions it is likely that considerable infection of the new canes may occur before the fruit is ripe. However, the virulence of the disease may be lessened in this way.

Spraying.— Judging from the results of experiments thus far made spraying is not a promising line of treatment; and yet, theoretically, the disease should be preventable by spraying. The chief difficulty seems to be to get the spray mixture to adhere to the canes. The new canes are covered with a "bloom" which causes the spray mixture to gather in drops and roll off. If spraying is done it should be commenced when the new canes are a few inches high and repeated at intervals of two weeks until about the middle of September, and again the following spring from the bursting of the buds to the setting of the fruit. In order to avoid spotting of the fruit and possible injury to the blossoms it may be necessary to abandon the spraying for about six weeks at fruiting time. It should be remembered that it is the canes and not the leaves which need protection. Bordeaux mixture is as likely to give good results as any other fungicide.

Other suggestions.— In setting plants suspected of being infected with cane blight remove as much as possible of the old cane and wash the roots. Destroy wild raspberry plants in the immediate vicinity of the plantation, since they may be a source of infection.

Some varieties are more resistant to cane blight than others and perhaps this fact may be turned to practical account. It is not now possible to give a list showing the relative susceptibility of different varieties; but it can be stated that among the varieties

commonly grown Cuthbert is one of the most affected and Columbian one of the least affected.

It is not always advisable to destroy a plantation because it has been seriously injured by cane blight. It may recover sufficiently to give profitable crops again. Since the disease does not attack the roots the new canes are just as vigorous in diseased plantations as in healthy ones, and if the weather conditions happen to be unfavorable to infection nearly a full crop may be obtained from plantations badly diseased the preceding season. The writers have known of instances of this kind.

II. RASPBERRY YELLOWS.

The Marlboro red raspberry, a once popular variety, is said by fruit growers to be "running out." In Ulster County particularly its culture is said to be no longer profitable; and throughout the Hudson Valley one frequently hears of the ravages of the "Marlboro disease." The foliage and fruit dry up — sometimes gradually, sometimes suddenly. There has been much speculation concerning the cause of the trouble.

According to our observations the so-called Marlboro disease is, in reality, two diseases. It is partly cane blight (to which the variety is much subject) and partly another disease for which we propose the name "Yellows." Plants attacked by yellows have a stunted, yellowish aspect suggestive of peach yellows and Woods' Bermuda lily disease, especially the latter. On fruiting canes the fruit-bearing laterals are dwarfed, often to one-half their normal length. The leaves are small, curled slightly downward at the margins and faintly mottled with yellow. Some of the berries dry up without ripening and those that ripen are undersized and insipid. Much of the foliage withers at the same time. New canes, for the most part, are not seriously checked in growth although their foliage is usually more or less affected. The foliage on new canes does not wither and there are rarely to be found any dead spots or areas. The leaves on the upper portion of the cane may be much mottled while those on the lower portion are nearly or quite normal. The reverse may also happen. Badly diseased canes and apparently healthy ones may

be occasionally found in the same stool. However, it is often difficult to determine whether a particular cane is or is not diseased because the transition from normal canes to badly diseased ones is by imperceptible gradations. Except in the later stages of the disease and when also attacked by cane blight, the canes themselves do not show injury. The roots, too, appear normal but more observations must be made before it can be stated positively that the roots are entirely unaffected.

This disease is a very important one and deserves more attention from pathologists than it has yet received. Although especially destructive to the Marlboro it is by no means confined to that variety. It has been observed on several other red varieties and black caps, among which are *Coutant No. 1,* Cuthbert and Kansas.

The name yellows is given the disease, not because of any supposed relation to peach yellows, but because it is descriptive of the appearance of affected plants. The red rust of blackberries and raspberries, due to the fungus *Cæoma nitens,* is sometimes incorrectly called yellows. For this disease, red or orange rust is the proper name inasmuch as it is caused by a true rust fungus.

The cause of raspberry yellows is not known. At one time we suspected that the red spider (*Tetranychus telarius*) was responsible for it, but that idea has been abandoned. It is safe to say that it is not caused by any fungus attacking the leaves. In an experiment made by this Station in coöperation with W. D. Barns & Son, of Middle Hope, N. Y., various combinations of commercial fertilizer were applied to the soil in a badly affected plantation without any appreciable effect on the disease. The details of this experiment will be given at a future time.

No remedy or preventive is known. On this subject it can only be said that spraying with bordeaux mixture does not check the disease. During the seasons of 1901 and 1902 the Station conducted a raspberry spraying experiment in coöperation with Mr. J. A. Hepworth of Marlboro, N. Y. The plantation contained 12 rows, 304 feet long, of the variety *Coutant No. 1.* Six of the rows were not sprayed while the other six were sprayed with bordeaux mixture, 1-to-10 formula, on the following dates in

1901: May 11, 22; June 3, 24, 26; July 10, 23; August 7 and 20. Three of the rows sprayed in 1901 were also sprayed in 1902 on May 10, 20, 31 and June 14.

The original object of the experiment was to ascertain if cane blight can be prevented by spraying; but, unfortunately, cane blight was almost wholly absent from this plantation in 1901 and 1902 although it had been destructive in 1900. Consequently, nothing was learned as to the value of spraying for cane blight. The yellows, on the other hand, attacked the plants over the whole plantation. The attack was a moderate one and a fair yield of fruit was obtained in spite of it; but in 1902 it was sufficiently severe to make it plain that the spraying had had no effect upon it. The three rows which had been sprayed 13 times were quite as much affected as the unsprayed rows.

EXPLANATION OF PLATES.

PLATE VI.—*A typical example of raspberry cane blight. A fruiting cane, variety Pride of Geneva, photographed, two-fifths natural size, June 21, 1901. The cane blight fungus attacked and killed the cane at the point indicated by the arrow. As a consequence, all foliage above this point withered.*

PLATE VII.—*Five new canes, variety Pride of Geneva, inoculated with a pure culture of the cane blight fungus* (Coniothyrium), *July 18, 1900. Photographed, natural size, September 18, 1900. Shows method of using grafting wax to cover inoculations. The discoloration of the bark above and below the wax was pronounced.*

PLATE VIII.—*Ten new canes of Cuthbert raspberry inoculated with a pure culture of* Coniothyrium *June 6, 1902. Photographed, natural size, August 9, 1902. Wax removed.*

PLATE IX.—*Four raspberry canes showing the discolored areas caused by* Sphærella rubina. *All natural size.*

FIG. 1.—*A new cane of Pride of Geneva. July, 1900. Bark brown.*

FIG. 2.—*A cane of the variety Talbot, showing spring appearance of the areas on fruiting canes. Bark gray and thickly covered with perithecia of* Sphærella rubina. *The majority of the perithecia contained only immature asci, but in a few spores were formed. Photographed April 22, 1902.*

FIGS. 3 AND 4.—*Fruiting canes of Whyte No. 7 and Carleton respectively showing spring condition of the areas. Bark gray and covered with perithecia of* Sphærella rubina, *mostly immature. On both canes a few* Phoma *pycnidia are intermingled with the* Sphærella *perithecia. Photographed April 18, 1902.*

PLATE X.—FIGS. 1-5, Sphærella rubina.

FIG. 1.—*A perithecium* × *87.*

FIG. 2.—*A fragment of one of the brown hypae from the base of the perithecium,* × *725.*

FIG. 3.—*An ascus* × *580.*

FIG. 4.—*Four ascospores* × *966.*

FIG. 5.—*A germinating ascospore* × *465.*

FIG. 6.—*Six spores of the* Phoma *found associated with* Sphærella rubina, × *966.*

FIG. 7.—*Ten spores of the raspberry cane blight* Coniothyrium, × *1033.*

FIG. 8.—*Ten spores of* Coniothyrium *sp. found on dead blackberry canes,* × *1033.*

All figures original and drawn with aid of camera lucida.

PLATE XI.—*The spraying outfit used in the experiment at Charlotte.*

PLATE VI.—RASPBERRY CANE BLIGHT.

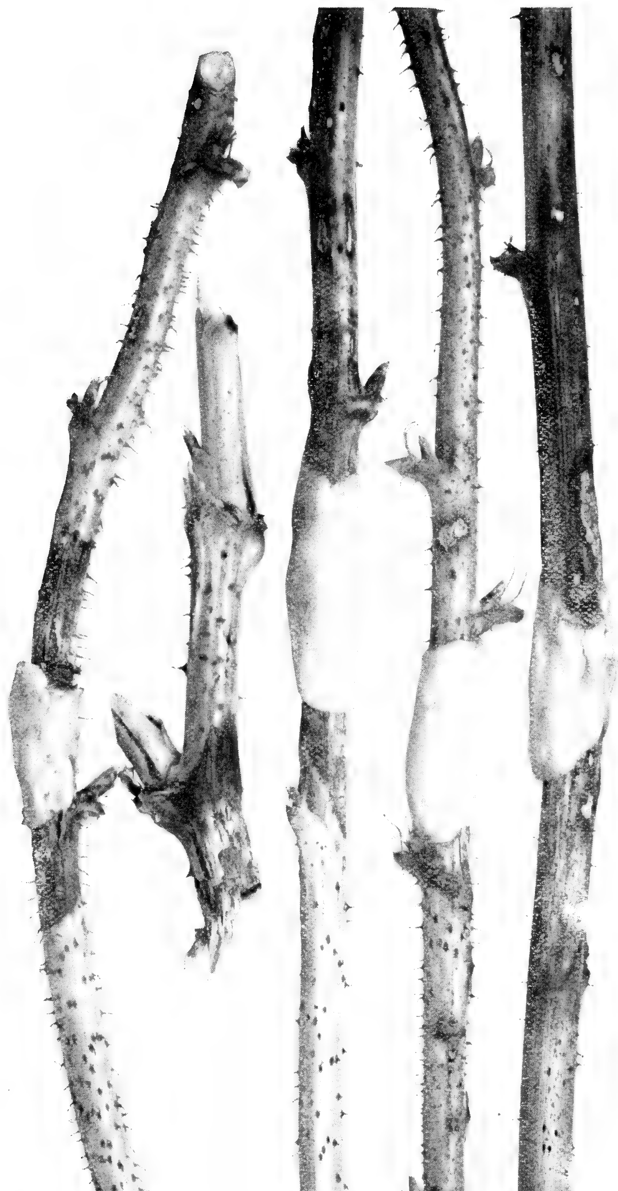

Plate VIII.—Results of Artificial Inoculation.

PLATE IX.—THE DISCOLORED AREAS CAUSED BY *Sphærella*.

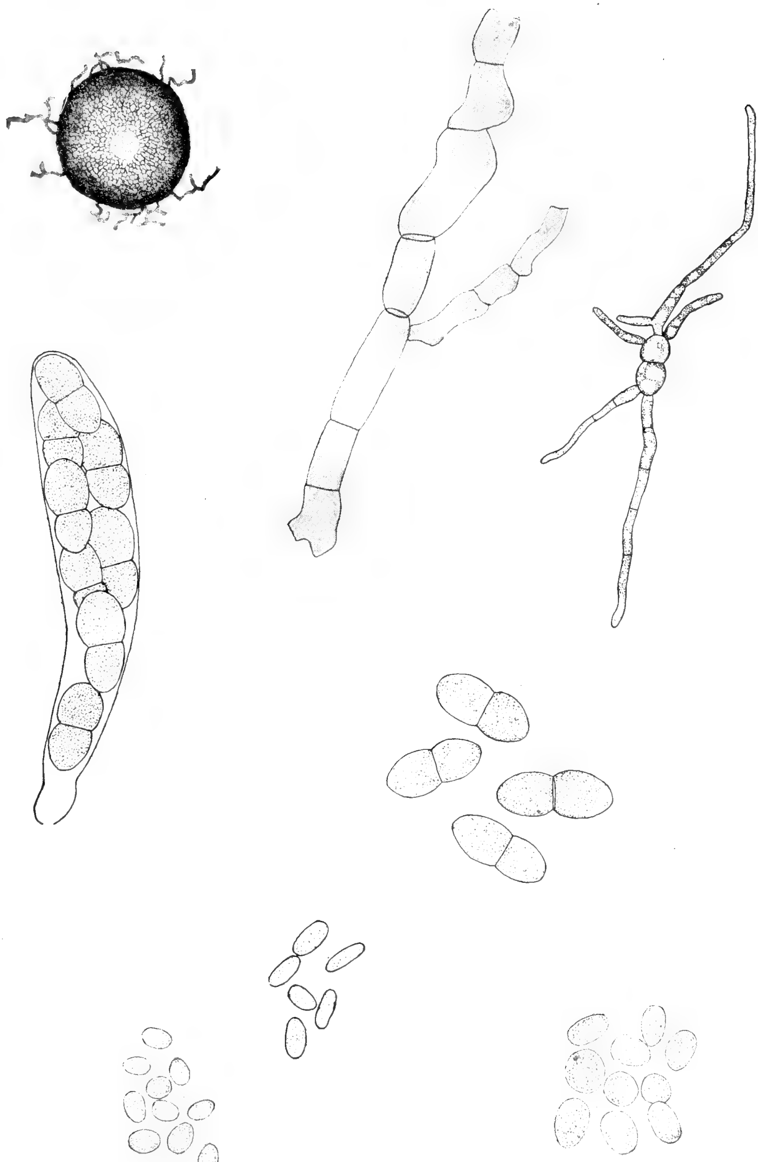

PLATE X.—*Sphaerella rubina, Coniothyrium* AND *Phoma.*

Plate XI.—Spraying Outfit Used at Charlotte.

A DESTRUCTIVE APPLE ROT FOLLOWING SCAB.*

H. J. EUSTACE.

SUMMARY.

Apple scab was unusually common in western New York during the past season. Early in the fall there developed upon many of the scab spots a white mildew-like fungus which caused a brown, sunken, bitter, rotten spot. There was no relation between the scab fungus and the rot-causing fungus except that the scab ruptured the epidermis of the apple, thus making an entrance for the rot fungus.

Traces of the disease could be found when the fruit was on the trees, but the greatest damage was done just after the fruit was harvested and packed.

Rhode Island Greening was affected more than other leading commercial varieties. Baldwin did not show the effects of the disease until late in the fall.

The trouble was probably more serious in western New York than in the other great apple-growing regions of the country.

The fungus which caused the rot has been known for many years, but always regarded as a saprophyte and of no economic importance.

The disease attacking apples at the time it did, after they had been harvested, barreled and ready to be sold, caused an enormous loss to growers, buyers and dealers.

Inoculation experiments proved that the fungus is parasitic on apple, pear, quince and grape. It is a wound parasite and cannot grow through sound epidermis; this explains its association with scab, as the scab ruptures the epidermis.

*A reprint of Bulletin No. 227.

The ideal preventive is to keep the fruit free from scab by thorough spraying. Cold storage will hold the disease in check, but it does not destroy the fungus, and the rot will develop when the fruit is taken into a warm place. The loss from the rot will be greatly reduced if the fruit is stored in a dry, well-ventilated house where the temperature can be kept at 45° F. or below. Dipping apples that were seeded with spores of the disease in solutions of copper sulphate and of formalin appeared to check the damage from this rot, but did not check the common soft rot or blue mold.

It is not believed that the disease will become epidemic except in very unusual and occasional seasons like the past, when all conditions favor its development. But the fact that orchards are now abundantly seeded with the spores of the disease make it important that apple growers spray more thoroughly to prevent scab the coming season than in the past.

INTRODUCTION.

Apple scab — a fungus disease familiar to all fruit growers — does more or less damage every year. Moist and cool seasons are very favorable to it. These conditions existed in 1902, and, as a result, the attack of scab was unusually severe. In orchards where a constant fight was not kept up against it by spraying the loss was enormous.

In August and September, while the fruit was still upon the trees, it was observed that on some of the scab spots there appeared a white or pinkish mildew-like fungus growth. A little later this growth produced a brown, sunken, bitter, rotten spot. On very scabby apples these rotten spots soon coalesced and the fruit became a mass of decay.

Some Fameuse apples affected with the disease were collected by the writer at Charlotte on August 30th and brought to the Station laboratory for study. The white mildew-like fungus on the scab spots was at once determined as *Cephalothecium roseum.* This was a surprise. The fungus had long been known, but had always been regarded as a saprophyte (a fungus that grows only on dead and decaying matter).

It was decided to carry on investigations with the fungus because the apple crop of the State is a very important one, and there were indications that damage of great economic importance would be done by the fungus. Then, too, the rot was of a very unusual nature, being caused by a fungus that was regarded as a saprophyte, and not known to be able to grow on living substances.

Many inquiries from fruit growers regarding the rot were received when the harvest commenced and the commercial importance of it began to manifest itself. In order to get information of the trouble at first hand, the writer made a trip into some of the great apple-growing sections of the State on October 13th, 14th and 15th, when the harvest was in full progress. Many dealers were visited, and all reported the trouble as very common and serious. Much interest was shown by apple growers and dealers generally, and for their information the following press notice was prepared. A copy was mailed to every newspaper in the State on October 21st, and published by most of them a few days later.

"A NEW AND DESTRUCTIVE APPLE ROT.

H. J. EUSTACE.

"An unusual and serious trouble with harvested apples has appeared in western New York. It is confined entirely to scabby apples. A white or pinkish mildew appears upon the scab spots and transforms them into brown, sunken, bitter, rotten spots. On very scabby apples these rotten spots soon coalesce and ruin the fruit.

" The damage done is enormous. In Niagara, Orleans, Monroe and Wayne counties thousands of barrels of apples have been ruined. The varieties most affected are Greening and Fall Pippin.

" Upon investigation it was found that the white mildew on the scab spots is the cause of the rot, and that it is a distinct fungus having no connection with the scab fungus. The scab itself will not rot a fruit, but it breaks the skin wherever it grows, and thereby makes an opening for this other fungus to get into the apple and rot it.

" Traces of the rot are sometimes found upon apples while still on the trees, but the greatest damage is done during the 'sweat-

ing process, either in piles on the ground or in barrels. Apples barreled immediately after picking and placed at once in cold storage seem to escape the trouble, but it is liable to appear later when the fruit is placed upon the market.

"A preventive of the rot is much to be desired, but at present none is known. Investigations in this line are now in progress at the New York Agricultural Experiment Station."

The whole trouble can be traced back to a lack of thorough spraying. Had the apples been kept free from scab by spraying, the white rot fungus could do them no harm in storage. However, the past season has been exceptionally favorable for scab and spraying has been less effective than usual.

During September and early October the parasitism of the fungus had been proven, and as a mater of scientific interest the following account of the fact was prepared on October 24th and published in "Science" for November 7th:

"THE PARASITISM OF CEPHALOTHECIUM ROSEUM.

"In discussions of the numerous fungi that are known to cause the rotting of apples and other fruits *Cephalothecium roseum,* Corda, has had but brief mention. It is generally regarded as a saprophyte, and Clinton* reports it as such on badly rotted apples. However, Aderhold** observed a case in which it caused a rotting of pears by growing through *Fusicladium pirinum* spots. But it has never been classed as a rot fungus of any economic importance.

"In New York State during the past season it has proved to be a true parasite and the cause of an apple rot of great economic importance. In some sections of the State thousands of barrels of apples have been ruined by it. Apple scab, *Fusicladium dendriticum,* has been unusually common this year. In September and October it was noticed that on many of the scab spots there appeared a white or pinkish growth which transformed them into brown, sunken, bitter, rotten spots. Upon investigation it was found that this white growth was *Cephalothecium roseum* Corda., and inoculations made upon many different varieties of apples and pears under antiseptic conditions, with pure cultures, have proved that it is parasitic, and the cause of the rot. In every inoculation the characteristic rot developed, while the same number of check fruits remained sound.

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* Clinton, G. P., "Apple Rots in Illinois," Ill. Agr. Exp. Station Bul. 69. 193. F. 1902.

**Aderhold, Rud., "Arbeiten der botanischen Abteilung der Versuchsstation des Kgl. pomologischen Instituts zu Proskau," *Centralbl. f. Bakt. Parasitenk. u. Infektionskr.,* II-Abt., 5:522. 1899.

PLATE XII.—*Cephalothecium* ROT.

"The common occurrence of this fungus upon the *Fusicladium* spots while it is wholly absent from other portions of the fruit is due to the fact that *Fusicladium* ruptures the epidermis and thus furnishes a means of entrance for the *Cephalothecium,* which could not otherwise attack the fruit, since it appears to be incapable of penetrating the unbroken epidermis.

"It is often found on apples while still on the trees; but after they have been harvested and left in piles on the ground or barreled and allowed to remain where the sweating process can take place, it has become so abundant on certain varieties as to ruin the fruit for storage.

"Further investigations are in progress; and when completed they will be published in a bulletin of the New York Agricultural Experiment Station.

H. J. EUSTACE.

GENEVA, N. Y., *October* 24, 1902."

DESCRIPTION.

As has been stated, the first case of the disease was found upon apples before they had been picked, but it was not until after they had been harvested that the great damage was done.

The first symptom was the white or pinkish fungus growth that appeared upon the scab spots. In a few days the surrounding tissues became brown and sunken and decay had started. These rotten spots soon grew larger, and where the scab spots were near together the rot soon coalesced and formed a large area of decay, often causing the complete ruin of the fruit.

The white growth continued and very soon covered all the scab spot, making it impossible to see where the scab had been. (Plates XIII and XIV.) In most cases a microscopic examination was necessary to determine the presence of the scab. The constant occurrence of this fungus upon the scab spots led many to believe that it was simply another form of the well-known scab. But there is absolutely no connection nor relation between the two. The only part that the scab had in the trouble was that it ruptured the epidermis (skin) of the apple, thus making an entrance for this fungus to grow into the tissue and cause the rot.

Later the white growth became pinkish, and the decayed area of the surrounding epidermis became larger, depressed and rup-

tured, lowering the market value of the fruit to a very large extent, and in many cases ruining it entirely. (Plate XV, Figs. 1 and 2.)

This fungus does not cause as rapid decay of the fruit as most of the more common ones do, such as blue mold, *Penicillium glaucum,* and bitter rot, *Gloeosporium fructigenum,* but works rather slowly as compared with these, and under more exacting conditions than most rot-producing fungi. The decayed spots are distinct, except where several have coalesced, circular in outline, and vary in diameter from the size of a pinhead up to an inch, or even more. A very prominent characteristic of this rot is that it is a very shallow-growing one; the decayed spots extend into the fruit but a little way. (Plate XVI.) In the more common rots of apples a large area of the fruit is rapidly affected, and the decay extends to the core and often beyond toward the opposite side, and usually the affected tissue is soft, whereas in this rot it is rather hard and cork-like and quite dry.

The taste of the decayed tissue caused by this fungus is also very characteristic, being decidedly bitter. This fact is of great importance in the manufacture of cider, for if apples affected with much of this rot are made into cider it will have a bitter taste, ruining its value as a beverage. It has been reported to us, but we have not made investigations to confirm it, that if the cider is to be made into vinegar the bitterness is not an objection.

After the apples had been harvested and were left in piles on the ground for a few warm days, it was observed that the disease had made very rapid progress in the bottom and interior of the pile, and that the fungus was in an exceedingly vigorous condition. But where the fruit had been barreled up tight and left in the orchard, as is the common practice, or was put in ordinary storage sheds, or shipped in ordinary freight cars, after a week or two it was discovered that the disease had made much more rapid progress, was more vigorous and had done greater damage than at any other time during the fall. It was also noticeable that the fruit in the bottom of large bins, such as are used about cider mills and drying houses, would become one mass of decay if allowed to remain there longer than a few days.

The reason for this is found in the fact that the fruit, being in piles, barrels or bins, was more or less shut off from a free circulation of air, thus allowing the sweating process to progress rapidly and vigorously, and the surrounding air quickly became moist and warm. These conditions greatly favored the rapid development of the disease.

VARIETIES AFFECTED.

There was a very marked difference in the susceptibility of different varieties of apples to the disease at the time of harvest, and even after they had been in storage for some time.

During the fall Rhode Island Greening, Fall Pippin and Fameuse were affected more than any other varieties. Much more was heard of the trouble on Rhode Island Greening than the other varieties named, but when it is remembered that this variety is far more extensively grown in New York State than the others and that the crop is more generally barreled and stored the reason is apparent. Much damage was done to Tompkins King, Maiden Blush and Twenty Ounce. Probably among the commercial varieties they would come after the three mentioned above. Cases came to our attention where more or less damage was done to Gano, Mammoth Black, McIntosh, Rambo, Quebec Winter Sweet and Winesap. Among the varieties not as well known, Baxter was very bad, and a Russian variety, Safstaholms, was completely ruined.

It was a singular fact that during the harvest time and for some weeks afterwards Baldwin and Northern Spy did not show any of the disease, although the scab had attacked them fully as much as it did the varieties that were badly affected with the rot early in the season. For the reason that these two varieties were not at all affected at the time the Rhode Island Greening and other varieties were decaying, it was generally believed that they were immune to the disease, but in December it was found that the disease had made its appearance on them. However, it was not nearly as vigorous nor as conspicuous as on the other varieties.

DISTRIBUTION.

Undoubtedly the disease was more common in western New York in 1902 than in any of the other great apple-growing regions of the country. However, it was not confined entirely to the western part of the State. On October 4th the writer found it doing damage to pears while still on the tree, at Cutchogue, Long Island.

In November letters giving a description of the disease and a photograph of an affected apple were sent to some of the members of the "National Apple Shippers' Association," asking if they had observed the trouble in their sections. Replies from Arkansas, Indiana, Kansas, Maine, Maryland, Missouri, Nebraska and Wisconsin were received, and all reported that there was no trouble from that disease in their regions during the fall. Specimens of diseased apples were received with a number of these replies, but in only one case, from Nebraska, was this disease found, and then only slight traces.

An apple buyer at Middleport, N. Y., informed the writer that he had observed the same disease in the Shenandoah Valley in 1901.

The trouble seems to be not unknown in Michigan. Prof. C. F. Wheeler, now of the Department of Agriculture, but formerly botanist at the Michigan Experiment Station, under date of November 10, 1902, informed the writer that there was considerable damage done by the disease in Michigan in 1901. In a letter to the writer, November 17, 1902, Dr. W. J. Beal, professor of botany at the Michigan Agricultural College, referring to this disease, says:

"We have been troubled with the same thing here to some extent for some time, but apparently worse than common this year, perhaps owing to the moist weather."

It has also been reported to us as occurring at several places in Ohio during the fall of 1902.

THE FUNGUS.

The fungus which is the cause of this rot is known as *Cephalothecium roseum* Cda., and was first described over sixty years ago. It is commonly found throughout Europe and America growing on various decaying substances, particularly on dead wood and rotting fruit. During all this time it has been well known to mycologists for its scientific interest, but until the past season[1] has been generally considered harmless and unable to cause the rotting of fruit or other healthy tissue. However, as long ago as 1866 Devaine,[2] a Frenchman, who investigated the decay of fruit, stated that a fungus which he determined as *Tricothecium domesticum* Fries grows readily when inoculated into green, solid fruits and the living leaves of certain plants. Zschokke,[3] in 1897, evidently believed that the fungus with which Devaine worked was identical with *Cephalothecium roseum*, and although he makes no mention of having conducted any inoculation experiments, he expresses the opinion that *C. roseum* does not belong to the true rot fungi. This author states that *C. roseum* is common on fruit which has first begun to rot from other causes. In only one instance did he find it unaccompanied by other fungi. Nothing is said about its association with *Fusicladium*, however. He placed some pears affected with *Cephalothecium* in a moist chamber and observed that the fungus did not penetrate any deeper into the tissue; also that it spread sidewise only slightly. His conclusions are that *Cephalothecium* had simply taken possession of sunburn spots.

Behrens,[4] in 1898, agrees with Zschokke that *Tricothecium* (*Cephalothecium*) is not a cause of rot in fruit, and suggests that Devaine worked with impure cultures. But Behrens, like Zschokke, made no inoculation experiments.

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[1]An account of the destructive apple rot discussed in this bulletin has already been published by John Craig and J. M. Van Hook in Cornell Experiment Station Bulletin No. 207 entitled, "Pink Rot: An Attendant of Apple Scab." The present writer had no knowledge that the disease was under investigation at the Cornell Experiment Station until the above mentioned bulletin was distributed, December 16, 1902.

[2]Devaine, M. C. Recherches sur la pourriture des fruits et des autres partes des vegetaux vivants. *Comptes Rendus*, **63**: 344. 1866.

[3]Zschokke, A. Ueber den Bau der Haut und die Ursachen der verschiedenen Haltbarkeit unserer Kernobstfruchte. *Landw. Jahrb. der Schweiz*, **11**: 174. 1897.

[4]Behrens, J. Beitrage zur Kenntnis der Obstfaulnis. *Centralbl. f. Bakt., Parasitenk. u. Infektionskr.* Zweite Abt., **4**: 581. 1898.

Aderhold,[5] in 1898, observed *Cephalothecium roseum* intimately associated with scab, *Fusicladium pirinum,* on pears in Germany. Although he, too, made no inoculation experiments, he expressed the opinion that in the case observed by him the *Cephalothecium* was really the cause of the rot. He confirmed Zschokke's observations that the fungus does not extend deeply into the flesh of the fruit, but confines its attacks chiefly to the surface layers.[6] Because of this character he named the rot "Schalenfaüle" (peel-rot).[7]

The spores of the fungus are borne at the tips of erect stalks, technically known as conidiophores. These grow from the mycelium, that part of the fungus which penetrates the tissues of the fruit and causes the rot. Both the spores and the conidiophores are colorless, except when old and seen in mass. They then have a pinkish color. The spores, which are two celled, are various in size and shape. Usually they are oblong-obovate and slightly constricted at the septum. (Plate XVII, Fig. 1.) As we have found them they measure 16 to 28 μ in length by 8 to 14 μ in width, the most common size being 21 by 10 μ.

Devaine stated that the fungus grew when inoculated into living leaves of certain plants, and Aderhold[8] has observed it on the leaves and living twigs of pear. This suggested that it may be present on apple leaves, especially those affected with scab, but we did not find a case where such a condition existed. We have looked for it on the twigs and limbs of apple trees, but have been unable to find it. On October 8th it was reported to us as growing on healthy maple trees[9] on Long Island. (Plate XVII, Fig. 4.) This suggests that it may be parasitic on maple trees. Investigations to determine this will be made during the season of 1903.

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[5]Aderhold, Rud. Arbeiten der botanischen Abteilung der Versuchsstation des Kgl. pomologischen Instituts zu Proskau. *Centralbl. f. Bakteriologie,* etc. Zweite Abt., 5: 522. 1899.

[6]This observation has been confirmed by the writer with affected apples that were left in moist chambers for a month.

[7]By fruit growers and apple buyers the rot is often called "canker," but this name is objectionable and should be abandoned since it is the generally accepted name of a common disease affecting apple limbs (See Buls. 163 and 185 of this Station). Craig and Van Hook (Cornell Exp. Sta. Bul. 207) have proposed the name "Pink Rot," which is probably as appropriate as any that can be found.

[8]Aderhold, Loc. cit.

[9]The complaint came from a nurseryman. The following is a part of his letter: "I am sending you a specimen of mildew on the trunk of Norway maple. The disease attacks sound old trees, without wounds, killing the bark."

Growing as a saprophyte it is common. During the past season we found it on the black knots on cherry and plum trees, and on cordwood (Plate XVII, Fig. 3), where it was very abundant and vigorous. During October we found it on the fruit pedicels of grapes, but whether it grew there as a saprophyte or as a parasite we are unable to say.

Jelliffe,[10] in his studies of the fungi found in the air, reports it as common.

With the fungus growing so abundantly in so many places it is proper to ask why has not this same trouble occurred in the past? That this fungus has been rotting apples to a very small extent in other years is altogether likely, as many apple dealers and buyers have told the writer that they have observed the same white growth and decayed spots on scabby apples in other years, but that the damage done was very slight; not enough to take any notice of. However, several dealers who have been in the business for many years state that there was a serious epidemic of the same disease in 1882.

Epidemics of fungus diseases like this one and the currant anthracnose[11] in the Hudson Valley in 1901 are not well understood. In the case of this apple rot it is universally attributed to the unusually wet season. This fact, coupled with the very large amount of scab, is really all the explanation that can be offered.

SEVERITY.

The damage done to the apple crop of New York in 1902 by scab was greater than in any recent season, certainly since 1894; and it probably caused a larger loss than did the memorable epidemic of that season. Formerly the presence of a little scab on an apple did not cause any alarm, for it is well known that the scab itself does not rot a fruit. But it does spoil its appearance and subsequent keeping quality. If apples of the required size have but a few spots of scab on them the price is reduced a little or they are sold as No. 2. If there is too much scab to pass for this grade they can be disposed of for evaporating purposes or

[10] Jelliffe, S. E. Some Cryptograms found in the Air. Bul. Torr. Bot. Club, 24: 481. 03 O. 1897.

[11] See Bul. No. 199 of this Station.

to be manufactured into cider. This unusual and untimely rotting caused by the sudden appearance of this fungus in a new rôle at once put all scabby apples, even those but slightly affected, into disrepute. The price dropped so low that in many cases it would have been money lost to pick and barrel them, and they were shaken from the trees and sold to evaporators at a very small price compared with what they would have been worth had there not been danger from loss on account of this rot.

At the same time the demand and price for good, clean apples increased, and growers who had any to sell realized a good profit for their thorough spraying and the extra work.

During October, when the greatest amount of damage was done, many of the newspapers of western New York contained articles indicating the severity of the disease and the alarm it was causing.

[From "The Democrat & Chronicle" of Rochester, Oct. 15, 1902.]

"MUCH DAMAGE FROM FUNGUS TO APPLES OF MANY ORCHARDS.

"A prominent fruit grower in Orleans county stated yesterday that the fungus on Greenings was doing great damage and bringing severe loss to many buyers, especially where stored in the ordinary storehouses, but that those put in cold storage warehouses, thus far, have kept well. North of Albion apples have been in some instances so badly affected with the fungus, they have been sold to the dry houses for comparatively small value. The question, said he, is, if the fungus is impairing apples now, what can be expected later in the season? Baldwins are not affected, but many other varieties are to some degree. The cause of the fungus is thought certainly to be from the unusually wet summer." * * * *

[From "The Union & Advertiser" of Rochester, Oct. 22, 1902.]

"APPLES DECAYING.

"RATHER BAD STATE OF AFFAIRS DISCOVERED BY WOLCOTT DEALERS.

"WOLCOTT, N. Y., *Oct.* 22.—The apple dealers of Wolcott are a badly discouraged lot these days over the rapid decay of apples which they have placed in storage. Early in the season the

immense storehouses of Wolcott began to be filled with barreled apples both from this section and also with large quantities which were shipped from the western part of the State. Early in the fall there was considerable alarm over a peculiar fungus which had attacked the apples, especially Greenings. Buyers were careful to avoid all these apples when placing them in storage, and supposed they had fruit of first-class keeping qualities. But now they find on opening their barreled fruit that it is decaying rapidly, although it is still early in the season.

"Wherever an apple shows the fungus spots they find a rotten spot, and even on apples where there is apparently no fungus there are signs of decay. Dealers are very loath to buy any more barreled stock, and business is slow at $1.25 per barrel.

"Many farmers who intended barreling their fruit are now preparing to send it to the evaporators, as evaporated apples are bringing good prices, and large quantities of coke have been stored by the evaporator men and there is very little loss because of the shortage of fuel."

Like all damage caused by fungus diseases, it is impossible to determine the extent of the loss or anywhere near it, but the experiences of the two parties referred to below may be taken as not uncommon, and will give some idea of how great and very unusual the trouble was.

Mr. H. G. Udell, of Brockport, said to the writer:

"We shipped two cars of apples from Brockport to Farmer to be put into cold storage. While on the road there were a few warm days and upon examination, before going into the cold storage house, they were found to be so badly diseased that they had to be sold for evaporating purposes."

Mr. L. Huston, of Lockport, said:

"I shipped a carload of Maiden Blush to St. Louis. The weather was warm and the apples were found to be ruined when they reached their destination."

INOCULATION EXPERIMENTS.

The parasitism of the fungus on apple, pear, quince and grape has been demonstrated by artificial inoculations. In all the inoculations the rot has always developed, while check fruits, kept under parallel conditions, always remained sound.

Pure cultures of the fungus obtained from apples and from cordwood were used in all of the inoculations. The same characteristic rot was produced whether inoculated with a culture made from a diseased apple or from the fungus as it was found growing as a saprophyte on cordwood.

The method of inoculation was as follows: The fruits were carefully selected and only sound, perfect specimens taken. They were sterilized by immersing in a 1-1000 solution of corrosive sublimate. This was washed off with distilled water and the surplus water was removed with a piece of sterilized cotton. In each case two fruits of the same variety were placed in a large, moist chamber that had been washed out with a 1-1000 solution of corrosive sublimate. The epidermis of each fruit was punctured with a sterilized needle. With another sterilized needle some of the fungus growing pure on slices of sugar beet, potato agar or apple agar was placed in the puncture of one fruit, the other being reserved for the check. (Plates XVIII and XIX.)

TABLE I.— INOCULATIONS ON FRUIT, WITH PURE CULTURES OF *Cephalothecium roseum.*

ON APPLES.

Date of inoculation.	VARIETY.	Date of examination.	Diameter of decayed area at point of inoculation.	Condition of check.
Sept.		Sept.	*Mm.*	
4	Fameuse	13	12	S'nd.
4	Fameuse	13	3	S'nd.
6	Grand Duke Constantine	13	6	S'nd.
6	Charlock Reinette	13	10	S'nd.
6	Okabena	13	6	S'nd.
6	Carolina June	13	5	S'nd.
6	Carolina June	13	4	S'nd.
13	Benninger	20	Sm'll.	S'nd.
13	Celestia	20	7	S'nd.
13	Ornament de Table	20	6	S'nd.
23	Fall Pippin	29	4	S'nd.
Oct.		Nov.		
22	Bismarck	7	10	S'nd.
22	Northwest Greening	7	15	S'nd.
Dec.		Dec.		
22	Pumpkin Sweet	29	8	S'nd.
22	Ontario	29	8	S'nd.
22	Thornton	29	5	S'nd.
22	Ben Davis	29	4	S'nd.
22	Stark	29	11	S'nd.
22	Shannon	29	5	S'nd.
22	Pewaukee	29	12	S'nd.
22	Rome Beauty	29	9	S'nd.
22	Deacon Jones	29	11	S'nd.
22	Tufts	29	5	S'nd.
22	Baker	29	5	S'nd.
Oct.		Oct.	*Mm.*	
7	Quebec Winter Sweet	22	7	S'nd.
7	Gravenstein	22	3	S'nd.
7	Maiden Blush	22	12	S'nd.
7	Fameuse	22	11	S'nd.
22	McIntosh	30	5	S'nd.
22	Patten Greening	30	8	S'nd.
22	Clarke	30	9	S'nd.
22	Covert	30	10	S'nd.
		Nov.		
22	Alexander	7	11	S'nd.
22	Centennial	7	5	S'nd.
22	Elgin Pippin	7	12	S'nd.
Dec.		Dec.		
22	Clarke	29	12	S'nd.
22	Jacobs	29	12	S'nd.
22	Boiken	29	13	S'nd.
22	Northern Spy	29	13	S'nd.
22	Baldwin	29	10	S'nd.
22	R. I. Green'g	29	8	S'nd.
22	King	29	12	S'nd.
22	Maiden Blush	29	12	S'nd.
22	Esopus Spitzenburg	29	5	S'nd.
22	Grimes Golden	29	7	S'nd.
22	Coon Red	29	3	S'nd.
22	Covert	29	9	S'nd.
22	Lady Sweet	29	7	S'nd.

ON PEARS.

Date of inoculation.	VARIETY.	Date of examination.	Diameter of decayed area at point of inoculation.	Condition of check.
Sept.		Sept.	*Mm.*	
23	Pitmanson Duchess	29	12	S'nd.
23	Fred'k Clapp	29	9	S'nd.
23	Victor	29	4	S'nd.
23	Raymond de Montlaur	29	4	S'nd.
23	Assomption	29	9	S'nd.
Oct.		Oct.	*Mm.*	
7	Raymond de Montlaur	22	25	S'nd.
7	Victor	22	21	S'nd.
7	Mad. von. Seibold	22	25	S'nd.

ON GRAPES.

Date of inoculation.	VARIETY.	Date of examination.	Diameter of decayed area at point of inoculation.	Condition of check.
Oct.		Oct.		
11	Agawam	22	Sm'll.	S'nd.
Oct.		Oct.		
11	Clinton	22	Sm'll	S'nd.

ON QUINCE.

Date of inoculation.	VARIETY.	Date of examination.	Diameter of decayed area at point of inoculation.	Condition of check.
Oct.		Oct.	*Mm.*	
7	Unknown	22	9	S'nd.

Inoculations conducted under the same sterile conditions as above described were made to determine if the fungus could penetrate the unbroken epidermis and cause the rot. Spores from a pure culture of the fungus were placed on one fruit without puncturing or breaking the epidermis, and on the other fruit inoculation was made by puncture, as previously described. The rot did not develop where the spores were placed on the unbroken epidermis, except in one case, and that was where a very tender-skinned variety was used. On all of the fruits inoculated by puncture the characteristic rot developed.

TABLE II.— INOCULATIONS MADE ON SOUND EPIDERMIS AND THROUGH A PUNCTURE.

Date of inoculation.	VARIETY.	Epidermis.	Date of examination.	Condition.
Oct. 11	Raymond de Montlaur*....	Sound.....	Oct. 22	Fruit sound.
11	Raymond de Montlaur*....	Punctured.	22	Rot developed.
11	Therese Appert*..........	Sound	22	Fruit sound.
11	Therese Appert*..........	Punctured.	22	Rot developed.
11	Golden Sweet	Sound.....	22	Fruit sound.
11	Golden Sweet	Punctured.	22	Rot developed.
11	Cox Pomona..............	Sound.....	22	Fruit sound.
11	Cox Pomona..............	Punctured.	22	Rot developed.
11	Small Admirable..........	Sound.....	22	Rot developed.
11	Small Admirable..........	Punctured.	22	Rot developed.
11	Mother	Sound.....	22	Fruit sound.
11	Mother	Punctured.	22	Rot developed.

* These two are pears, the others are apples.

The results of these inoculations indicate that the fungus is more properly classified as a wound parasite rather than as a true parasite.

Experiments were made to determine whether the disease would work more vigorously when inoculation was made upon a scab spot or by puncture through healthy epidermis. As in the other experiments, two fruits of each variety were used — one on which there was a fair-sized scab spot, the other with the epidermis all sound. Inoculation was made by placing the spores from a pure culture of the fungus upon the scab spot of one fruit and by puncture in the usual way on the sound fruit.

TABLE III.— INOCULATIONS MADE ON SCAB SPOT AND THROUGH HEALTHY EPIDERMIS.

Date of inoculation.	VARIETY.	How inoculated.	Date of examination.	Diameter of decayed area at point of inoculation.
Oct. 23	Twenty Ounce	On scab	Nov. 6	10 Mm.
23	Twenty Ounce	By puncture	6	4 Mm.
23	Holland	On scab	6	10 Mm.
23	Holland	By puncture	6	6 Mm.
23	Jewett fine red	On scab	Dec. 3	6 Mm.
23	Jewett fine red	By puncture	3	6 Mm.
23	Hargrave	On scab	Nov. 7	15 Mm.
23	Hargrave	By puncture	7	6 Mm.
23	Grundy	On scab	7	20 Mm.
23	Grundy	By puncture	7	18 Mm.
23	Jonathan	On scab	7	30 Mm.
23	Jonathan	By puncture	7	25 Mm.
23	Disharoon	On scab	7	13 Mm.
23	Disharoon	By puncture	7	20 Mm.
23	Gano	On scab	7	25 Mm.
23	Gano	By puncture	7	14 Mm.
23	Mother	On scab	7	5 Mm.
23	Mother	By puncture	7	20 Mm.
23	Fanny	On scab	7	5 Mm.
23	Fanny	By puncture	7	20 Mm.

While the results of these experiments do not show uniformity, in most cases a larger area of the rot developed on the fruits inoculated on a scab spot than where inoculation was made through healthy epidermis. This is probably because more of the epidermis is broken by the growth of the scab and the rot fungus has a better chance to spread out than where only a puncture the size of a needle is made through sound epidermis.

In all of the artificial inoculations it was observed that the rot extended into the fruit much farther than it did in natural infections.

The identity of the fungus produced in all the artificial inoculations was determined by a microscopic examination; also by tasting the diseased tissue. And in many cases cultures were made of some of the affected tissue, removed under sterile conditions, and the fungus reproduced. In nearly every case these cultures were absolutely pure.

PREVENTIVE MEASURES.

Spraying.—Apples that were free from scab were entirely free from this rot. Observations and investigations go to show that the fungus which causes the rot cannot grow through the sound epidermis. Scab growing on an apple breaks the epidermis and thereby makes an entrance for this rot fungus as well as for various other kinds of fungi that cause the decay of the fruit. Therefore, the ideal preventive is to keep the fruit free from scab. Spraying will do this, as many experiments and the experience of the most successful apple growers in New York State prove.

The standard preventive for scab is three thorough applications of bordeaux mixture; the first applied just before the blossoms open, the second just after the blossoms fall and the third from ten to fourteen days after the second application.

For further details and suggestions on spraying see Bulletin 170 of this Station.

Cold storage.— Investigations that have been made demonstrate that the rot on fruit known to be seeded with spores of the disease can be successfully held in check by cold storage.

There were reasons for believing this to be so, but positive evidence was lacking. To get this evidence twelve apples of different varieties that had been carefully selected and sterilized were inoculated with a pure culture of the fungus on the morning of November 1st, and that afternoon taken to Brighton and placed in the commercial cold storage house of the Gleason & Loomis Co., where the temperature was kept constantly at about 32° F. Check fruits of the same varieties, inoculated in the same way, at the same time and from the same pure culture of the fungus were made and left in the laboratory, where the temperature was about 70° F. during the day, but considerably lower during the night.

On November 10th the apples in the laboratory were examined, and in every one the rot had developed at the point of inoculation. (Plate XX, Fig. 1.)

On November 28th the apples in cold storage were taken out and found to be in as good condition as when they were put in. (Plate XX, Fig. 2.) The rot had not developed in any of them. But after these apples had been in the laboratory a few days the

rot began to develop around the point of inoculation in every fruit. (Plate XX, Fig. 3.)

This is conclusive proof that the low temperature of the cold storage house will hold the disease in check, but that it does not kill the spores of the fungus, and as soon as the fruit is taken into a warm place the rot begins to develop.

Therefore, the recommendation is made that if it is desired to hold the rot in check, fruit believed to be seeded with spores of the disease be put into cold storage just as soon after it is picked as possible and not taken out until wanted for immediate use.

Dryness and low temperature.—While commercial cold storage may not be feasible in many cases, certain conditions can be made that will very much decrease the amount of damage that this fungus can do.

It is of the greatest importance that any building intended as a storehouse for fruit be dry and well ventilated. In every case of the disease that has come to our notice the damage done was very much greater where the fruit was stored in a room or building that was damp and poorly ventilated.

In experiments that we have made by putting cultures of the fungus in a room in which the temperature ranged from 41° to 46° F., the average being 44°, there was no growth at the end of a week. The cultures were then taken out and placed in a warm room and made a good growth in one day.

In a temperature between 50° and 60° F., the average being 56½° F., there was a small growth of the fungus at the end of a week.

These observations and experiments indicate that if fruit is stored in a building or room that is dry and well ventilated, and the temperature kept at 45° F. or below, the growth of this fungus will be retarded and the fruit saved from the rot.

Dipping the fruit.— Theoretically, if a fruit seeded with the spores of a destructive fungus disease is dipped in some solution known to be able to kill the spores, the liability of damage to the fruit from the fungus diseases ought to be greatly reduced.

Experiments to determine the practicability of this theory have been made. Rhode Island Greening apples badly affected with the scab were secured for the work. This variety was selected

because it is a very prominent commercial one and was more susceptible to attacks of the rot fungus than the other. That the experiment might be of commercial value, barrel quantities of the apples were used for each different treatment. The apples were treated on October 17th, 18th and 20th. Solutions of copper sulphate and of formalin were used.

TABLE IV.— EXPERIMENTS IN DIPPING APPLES.

Date.	Barrel.	Time immersed.	Solution.
Oct. 17	1	5 minutes...	1 lb. copper sulphate to 50 gallons of water.
17	2	10 minutes...	1 lb. copper sulphate to 50 gallons of water.
17	3	5 minutes...	2 lbs. copper sulphate to 50 gallons of water.
17	4	10 minutes...	2 lbs. copper sulphate to 50 gallons of water.
18	5	5 minutes...	3 lbs. copper sulphate to 50 gallons of water.
18	6	10 minutes...	3 lbs. copper sulphate to 50 gallons of water.
20	7	30 minutes...	3 lbs. copper sulphate to 50 gallons of water.
17	8	5 minutes...	4 lbs. copper sulphate to 50 gallons of water.
17	9	10 minutes...	4 lbs. copper sulphate to 50 gallons of water.
20	10	30 minutes...	4 lbs. copper sulphate to 50 gallons of water.
20	11	10 minutes...	5 lbs. copper sulphate to 50 gallons of water.
20	12	30 minutes...	5 lbs. copper sulphate to 50 gallons of water.
20	13	10 minutes...	6 lbs. copper sulphate to 50 gallons of water.
20	14	30 minutes...	6 lbs. copper sulphate to 50 gallons of water.
20	15	10 minutes...	8 lbs. copper sulphate to 50 gallons of water.
20	16	30 minutes...	8 lbs. copper sulphate to 50 gallons of water.
20	17	5 minutes...	10 lbs. copper sulphate to 50 gallons of water.
20	18	10 minutes...	½ pint formalin to 30 gallons of water.
20	19	30 minutes...	½ pint formalin to 30 gallons of water.
18	20	5 minutes...	1 pint formalin to 30 gallons of water.
18	21	10 minutes...	1 pint formalin to 30 gallons of water.
17	22	Check	Not treated at all.
18	23	Check	Not treated at all.
20	24	Check	Not treated at all.
20	25	Check	Not treated at all.

After the apples were taken out of the solutions and were dried off by exposure to the sun and wind, they were barreled and the barrels piled on the north side of a building and covered with boards as a protection against rain. Before there was danger from freezing they were taken into a dry, cool storeroom.

On December 2d the apples in each barrel were examined, and it was very apparent in comparing the treated ones with the checks that the solutions of copper sulphate and of formalin had materially checked the growth of the *Cephalothecium*. However,

the common, soft rot caused by the fungus *Penicillium glaucum* had made its appearance in every barrel of apples, but it was somewhat more abundant in those that had been treated.

These treatments must be regarded as very severe tests. They were not made until late in the season, probably too late for the best results. The apples were very scabby, and in a few cases they were not dried off as thoroughly as was desirable. But it is not expected that scabby apples can be kept free from the common soft rots very long, and the fact that these apples were wet even with a solution supposed to prevent the germination of the spores that caused the soft rot appears to have actually hastened its growth and increased the damage it does.

As a commercial practice, dipping fruits in solutions of copper sulphate or of formalin to check the damage that might be done by fungus diseases is not to be recommended. While there is no doubt that many spores of the diseases are killed, wetting fruits, even with a disease preventive, appears to increase the damage from the common soft rot or blue mold.

It was an interesting fact that none of the solutions used injured the skin of the apples in any way.

Recapitulation.— Spray thoroughly to prevent apple scab.

In picking, sorting and packing, discard all fruits that show any of the white or pinkish growth.

The development of the rot is greatly favored if scabby apples are left in piles on the ground, or barreled and allowed to stand where it is only moderately warm.

Get the fruit into storage as soon after picking as possible.

Store the fruit in a dry place and keep the temperature below 45° F. if possible.

Cold storage simply retards the growth of fungi that cause the various decays of fruits. As soon as the fruit is taken into a warm place the spores of the fungi at once begin to grow, and decay results. Therefore, it is advisable to leave the fruit in storage as long as possible before it is wanted for use.

THE OUTLOOK FOR THE FUTURE.

All things considered, this is probably the most unusual and remarkable epidemic of a fungus disease that has ever occurred in this country — certainly of any on record. The unusualness lies in that fact that it was caused by a fungus that has been well known for many years as a saprophyte, and supposed to be of no economic importance, but in the past season suddenly becoming a parasite of wide distribution, attacking apples and causing an enormous loss to the crop of the State.

Fruit growers are anxious to know if the same trouble is liable to appear the coming season, and if it is liable to occur regularly every year hereafter and become a menace to the apple industry. Of course this cannot be predicted with certainty, but it is our opinion that the apple growers need not feel uneasy about the disease becoming a regular pest. There is evidence that the same disease has caused damage to apples in past years, but is has been so slight as to be overlooked. Judging from what is known of its history, it seems unlikely that it will become troublesome except in occasional and very unusual seasons like the past one, where all conditions favor it. However, the fact that orchards are now abundantly seeded with the spores of this disease must not be lost sight of, and for this reason apple growers are advised to spray more thoroughly, to prevent the scab, during the coming season than in the past. The rot may not become epidemic again in many years, but the fact that it was so abundant in 1902 is certainly favorable for its appearance in 1903 if the weather conditions are similar to those of the past season.

ACKNOWLEDGMENT.

It is with pleasure that I acknowledge my indebtedness to Mr. F. C. Stewart, Botanist of this Station, without whose interest and help this work would not have been done.

EXPLANATION OF PLATES.

PLATE XIII.—*Rhode Island Greening apples affected with the* Cephalothecium *rot. Average specimens from many bushels after they had been in ordinary storage four weeks.* Slightly reduced.

PLATE XIV.—*Fameuse apples affected with the rot. Average specimens from a bushel offered for sale at a grocery, in Geneva, October 6, 1902.* Slightly reduced.

PLATE XV.—*Medium and late stages of the rot:*

FIG. 1.—*Fall Pippin apple after it had been in ordinary storage four weeks.* Natural size.

FIG. 2.—*Rhode Island Greening apple photographed December 23, 1902. Had been in ordinary storage since harvested.* Natural size.

PLATE XVI.—*An affected Rhode Island Greening apple and cross-section of the same illustrating the shallow-growing character of the rot.* Natural size.

PLATE XVII.—*The fungus,* Cephalothecium roseum:

FIG. 1.—*Spores* $\times$ *1000.*

FIG. 2.—*Petri dish culture on potato agar.*

FIG. 3.—*Growing as a saprophyte on cord-wood.*

FIG. 4.—*Growing on bark of Norway maple.*

FIGS. 2, 3 AND 4.—Natural size.

PLATE XVIII.—*Artificial inoculation on apples, variety Stark.*

FIG. 1.—*Seven days after inoculation with a pure culture of* Cephalothecium roseum. Natural size.

FIG. 2.—*Check. Point of puncture below and to the right of the stem.* Natural size.

PLATE XIX.—*Artificial inoculation on pears, Pitmanson Duchess.*

FIG. 1.—*Two weeks after inoculation with a pure culture of* Cephalothecium roseum. Natural size.

FIG. 2.—*Check. Point of puncture below the figure on pear.* Natural size.

PLATE XX.—*Influence of cold storage. Rhode Island Greening apples inoculated with a pure culture of the apple-rot fungus.* Slightly reduced.

FIG. 1.—*Inoculated and kept in the laboratory.*

FIG. 2.—*Inoculated at the same time as apple in Fig. 1, but kept in cold storage for four weeks. Photographed soon after taken out.*

FIG. 3.—*Same apple as in Fig. 2, after it had been in a warm room some time.*

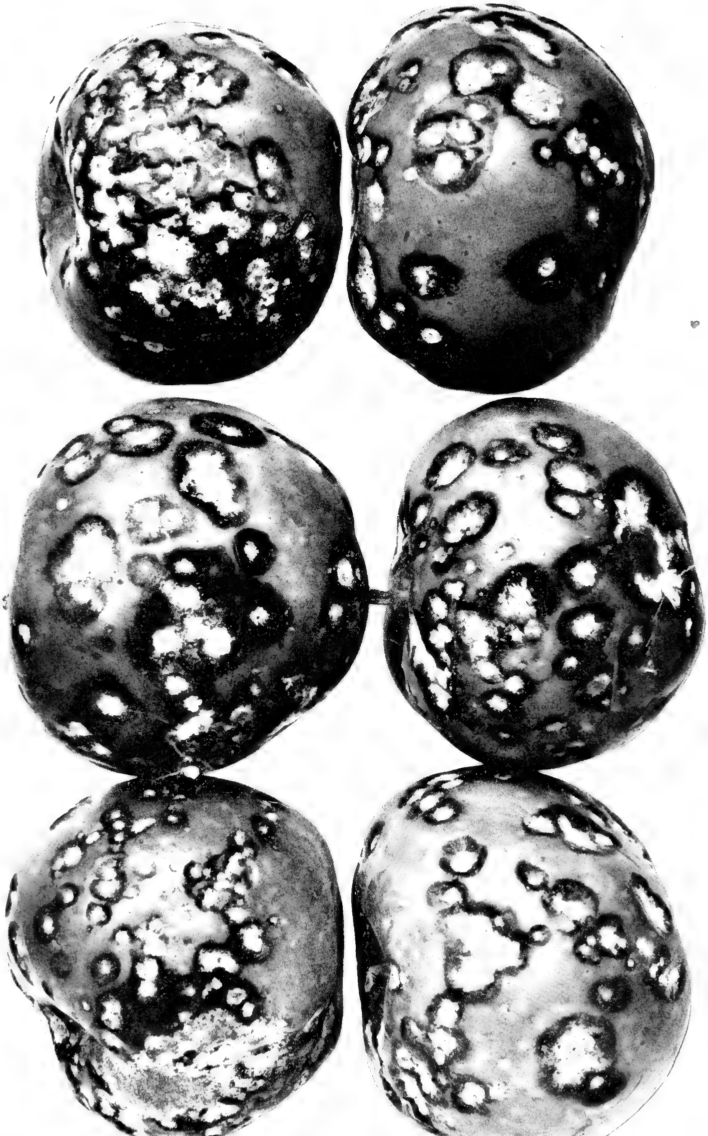

Plate XIII.—Greening Apples Affected with the Rot.

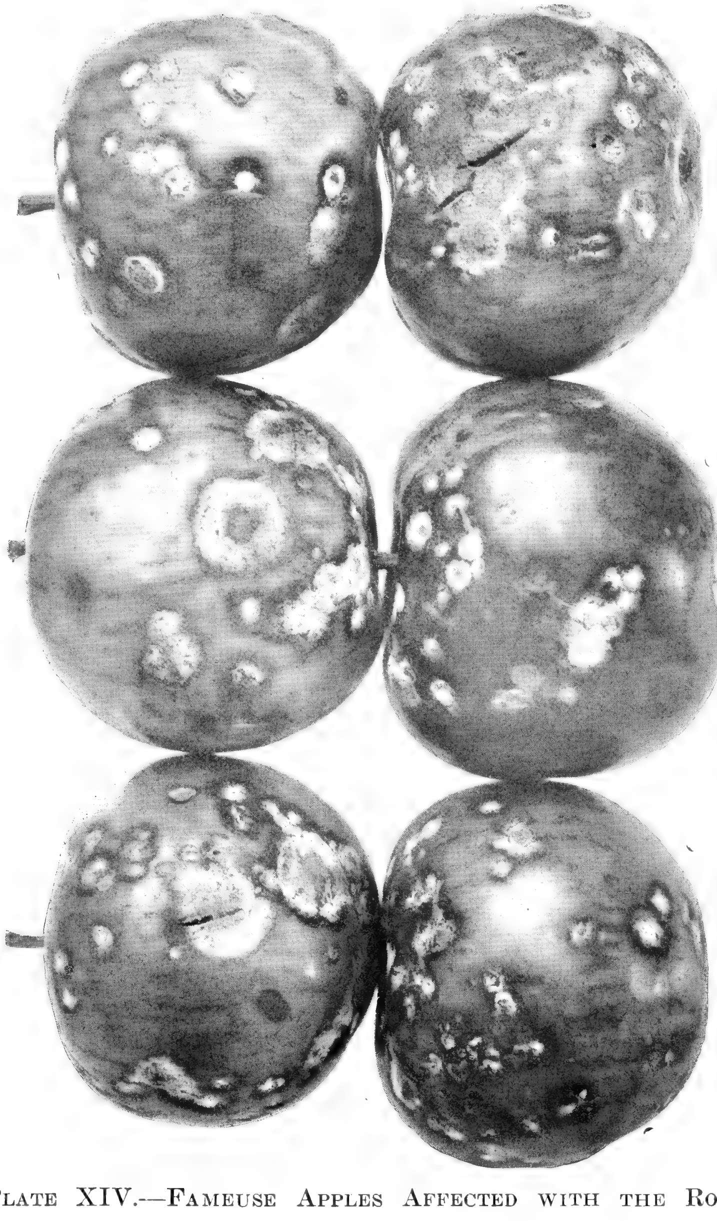

PLATE XIV.—FAMEUSE APPLES AFFECTED WITH THE ROT.

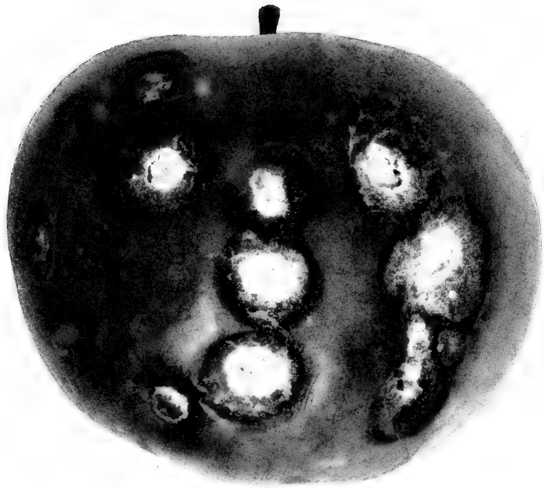

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PLATE XV.—MEDIUM AND LATE STAGES OF THE ROT.

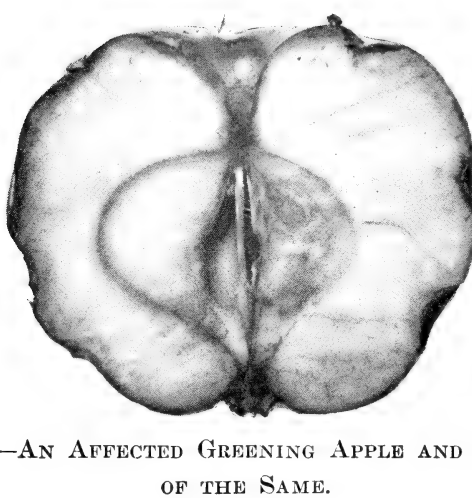
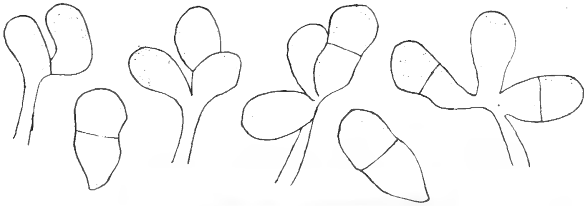


PLATE XVI.—AN AFFECTED GREENING APPLE AND CROSS-SECTION OF THE SAME.

1



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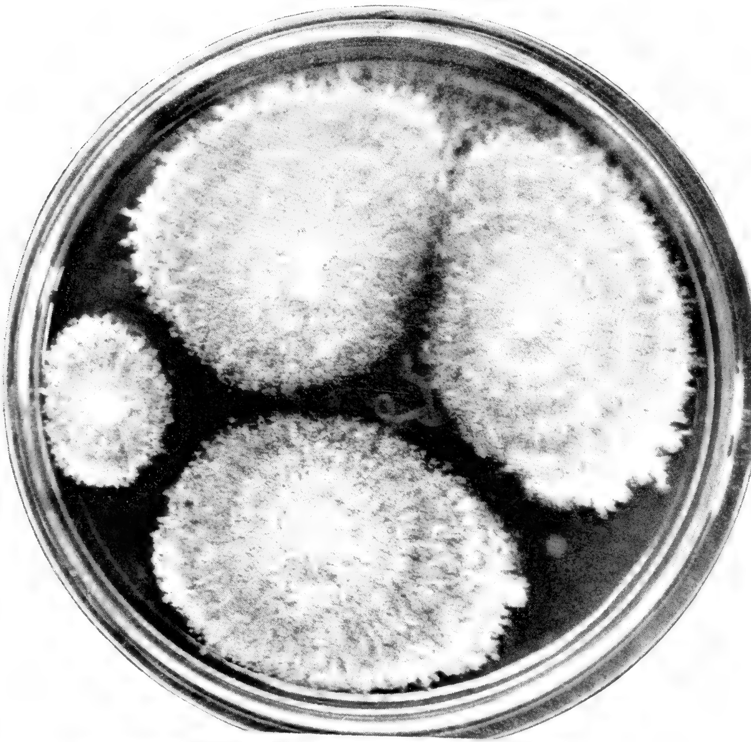

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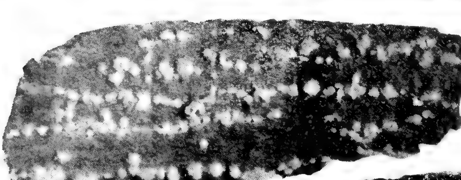

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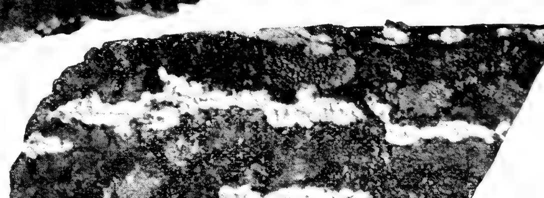

Plate XVII.—The Fungus, *Cephalothecium roseum.*

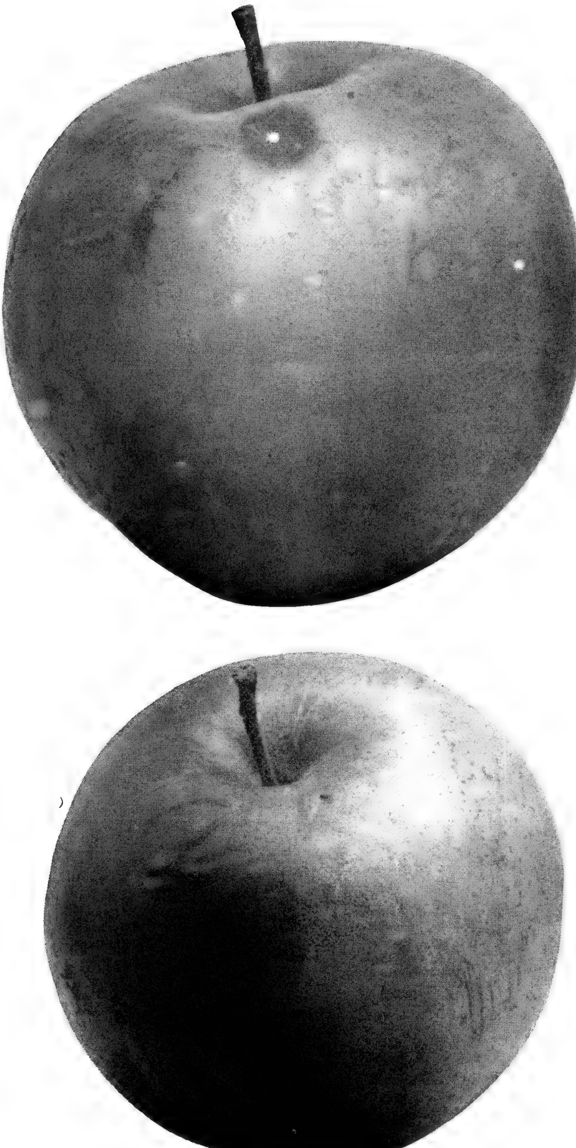

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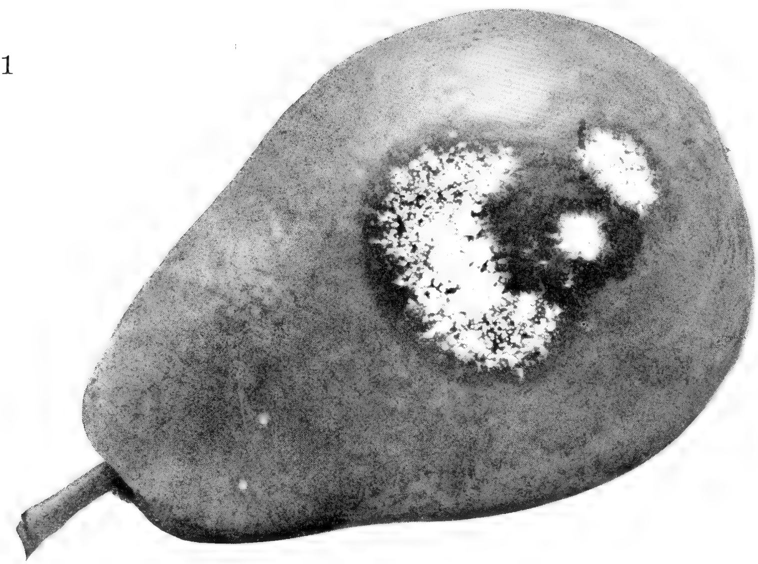
PLATE XVIII.—ARTIFICIAL INOCULATION ON APPLES: 1, INOCULATED; 2, CHECK.

1



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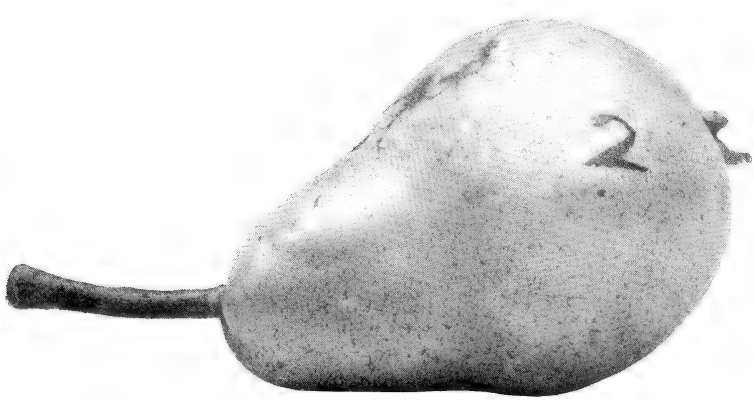

Plate XIX.—Artificial Inoculation on Pears: 1, Inoculated; 2, Check.

1

2

3

Plate XX.—Influence of Cold Storage.

REPORT

OF THE

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Table of Contents.

[1]Absent on leave after November 1, 1902.
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REPORT OF THE CHEMICAL DEPARTMENT.

A STUDY OF SOME OF THE SALTS FORMED BY CASEIN AND PARACASEIN WITH ACIDS: THEIR RELATIONS TO AMERICAN CHEDDAR CHEESE.*

L. L. VAN SLYKE AND E. B. HART.

SUMMARY.

1. The object of the work described in this bulletin is to study the real function of acids in relation to the important changes taking place in cheese-curd during the cheddar process of cheese-making.

2. In examining cheese for hetero-caseose by extraction with dilute solution of common salt, a body was found in quantities so large as to indicate that it was some compound other than hetero-caseose.

3. In studying cheese made with and without the use of lactic acid, the salt-soluble product was discovered to be present in very large quantities only when acid was used, being practically absent, or present in very small proportions, when no acid was used.

4. In normal cheese the salt-soluble product is always found, but in varying quantities, being largest usually in new cheese,

*A reprint of Bulletin No. 214.

and diminishing with age of cheese. Various conditions affect the amount in new cheese, especially those conditions influencing the amount of acid present.

5. Paracasein, carefully prepared and treated with dilute lactic acid, furnishes a product resembling, in both physical and chemical properties, the salt-soluble substance extracted from cheese.

6. Paracasein is shown to combine with an acid in at least two different proportions, forming two distinct compounds; one is the unsaturated or mono-acid salt; the other, the saturated or di-acid salt. Such compounds were prepared with lactic, acetic, hydrochloric, and sulphuric acids.

7. Casein forms salts with acids in the same manner as paracasein.

8. The unsaturated salts formed by casein and paracasein with acids are soluble in dilute solutions of sodium chloride and in 50 per ct. hot alcohol, but insoluble in water. The saturated salts are practically insoluble in water, dilute salt-solutions and 50 per ct. hot alcohol. Both forms are sparingly soluble in dilute solutions of calcium lactate and calcium carbonate.

9. The important changes taking place in cheese-curd during the process of cheddar cheese-making, such as the acquired ability to form strings on hot iron, the changes in appearance, plasticity and texture, and probably the shrinking, are due to the formation of the unsaturated paracasein lactate.

10. The ripening process in normal cheddar cheese, by which the insoluble nitrogen-compounds change into soluble forms, begins, not with paracasein as has been universally held, but with unsaturated paracasein lactate. The water-soluble nitrogen in cheese generally increases as the unsaturated paracasein lactate decreases, and apparently at the expense of the latter compound. The first step in the normal ripening process of American cheddar cheese is probably a peptic digestion of unsaturated paracasein lactate. Some of the facts presented suggest a method of proof of the commonly accepted theory of gastric digestion.

INTRODUCTION.

The chemical changes taking place during the early stages of manufacture of cheese have hitherto been little investigated or understood. This is particularly true of the kind of cheese most extensively made in the United States and Canada, commonly called American cheddar cheese. One of the first recognized changes occurring in the process of cheese manufacture is that produced by the action of rennet on milk-casein, resulting in the formation of an insoluble curd. The action of rennet, according to Hammarsten's explanation, splits milk-casein into two different compounds[1], — one, the insoluble curd, called paracasein, formed in large proportions; the other soluble, albumose-like, called whey proteid, formed in small proportions. While Hammarsten's view is still held by many, there is growing evidence[2] that the albumose-like proteid found in whey is not a result of the action of rennet, but that it can be produced by actual proteolytic digestion of casein, due to enzymes either present in the milk itself or introduced with the rennet (as pepsin or Glaessner's pseudo-pepsin). Whatever we may ultimately find to be the exact nature of rennet action on milk-casein, it is not the only factor at work during and after the formation of the insoluble curd; for there is present at least one other active process during the early stages of cheese-making that has much to do with the production of a "good curd", judged from the practical standpoint of a cheesemaker.

One of the first operations in cheddar cheese-making is to "ripen" the milk previous to adding rennet. This is accomplished by allowing the milk to stand some time at a temperature of about 86° F. (30° C.), or the operation may be hastened by adding to the milk special cultures of acid-producing organisms. This process, commonly known as the "ripening of milk," has for some time been recognized as an acid-producing form of fermentation, that is, a fermentation brought about by the action of lactic-acid organisms on the milk-sugar, resulting in the formation of lactic acid. In ripening milk, the cheesemaker increases

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[1]*Maly's Ber.*, 2: 118 (1872); 4: 135 (1874).

[2]Fuld. *Beitrage zur Chim. Physiol.*, 2: 169 (1902).

the quantity of acid in the milk, not only before adding rennet, but continuously throughout the rest of the process of manufacture.

The amount of acid in cheese-curd is roughly measured in a mechanical way by means of the so-called "hot-iron test." When a piece of curd is pressed against a hot iron and then drawn away carefully, fine, silky threads are formed, adhering to the iron. This phenomenon is closely associated with the formation of acid and the length of the strings shown by the hot-iron test is utilized as a measure of the amount of acid present and as an indication when to perform certain operations. Thus, when the curd strings on the hot iron to the length of one-eighth of an inch, the whey is removed from the curd, after which the curd is "packed" in a pile and allowed to lie until it has passed through the so-called "matting" or "breaking-down" process, when it furnishes strings an inch or more in length by the hot-iron test. When this stage is reached, the remaining steps of the manufacturing process are at once completed, such as milling, salting, and putting in molds for pressing.

While it has been generally supposed that the presence of some acid, presumably lactic acid, in the cheese-making process is, in some way or other, responsible for the most important changes taking place, such as the shrinking of the curd, the acquired ability to form strings on hot iron and the change in appearance and plasticity of curd, no one has ever been able to show in what way these changes were brought about by acids. It has been commonly supposed that the observed changes were purely physical in character and were not the result of chemical changes in the curd. In the following pages it is our purpose to consider more fully than has been done previously the real function of acids in relation to the important changes taking place in cheese-curd during the cheddar process of cheese-making.

Since Sjöquist's[3] investigation, we have learned that proteids can build salts with acids and bases, and this subject has been considerably developed in the last few years. Bugarszky and Liebermann[4] have shown that egg-albumin forms with hydrochloric acid a salt analogous to ammonium chloride, which they call

[3]*Skandin. Arch. f. Physiol.*, 5: 277 (1894).
[4]*Pfluger's Archiv*, **72**: 51 (1898).

albuminum chloride. Osborn[5] has also shown that edestin, the globulin of hempseed, is capable of combining with acids in several different proportions, forming salts having different properties. Panormoff[6] also has recently described definite compounds formed by egg-albumin with different acids. So far as we are able to learn, no similar work with milk-casein or with paracasein (milk-casein coagulated by rennet and constituting a large proportion of cheese-curd) has been done. The nearest any one has come to touching this specific line of work was in the case of Danilewsky[7], who, in his preparation, by use of hydrochloride acid, of what he called pure casein, actually prepared a mixture of the salts of this proteid, one of which is soluble in 50 per ct. boiling alcohol, while the other is insoluble. From this behavior, he concluded that milk-casein consists of two proteids. Reference will again be made to this.

In our early work relating to the study of chemical changes taking place in cheese during the process of ripening or curing, we mixed the cheese thoroughly with sand by grinding in a mortar and completely extracted this with water at 131° F. (55° C.). The residue, insoluble in water, was then treated with a 10 per ct. solution of sodium chloride at 104° F. (40° C.) for the purpose of removing any hetero caseose formed during the ripening process. Chittenden[8] had shown that, in a peptic digestion of casein, hetero-caseose was formed only in small amounts. When, by our extraction of fresh or partly ripened cheese with dilute salt solution, we obtained amounts of proteid, representing often as high as 40 per ct. of the total nitrogen present in the cheese, it became apparent that we were dealing with some compound other than hetero-caseose.

DISCUSSION OF EXPERIMENTS.

OCCURRENCE OF THE SALT-SOLUBLE PRODUCT IN CHEESE MADE IN THE PRESENCE OF CHLOROFORM WITH AND WITHOUT ACID.

(*1*) *Without acid.*— Cheeses were made from milk which had been previously heated to 208° F. (98° C.) for the purpose of

[5] Ann. Report of Conn. Agr. Exp. Sta. **23**: 402 (1900).
[6] *Jour. d. Russ. Phys. Chem. Gesellsch.*, **31**: 556.
[7] *Zeit. f. Physiol. Chem.*, **7**: 433 (1883).
[8] Studies in Physiol. Chem. Yale Univ. **2**: 156 (1885–6).

destroying all enzymes and bacterial forms present in the milk. After cooling the milk to the temperature employed in cheese-making, chloroform was added to the milk to the extent of 4 per ct. by volume in order to prevent any bacterial activity. As the ability of the milk-casein to coagulate with rennet is impaired by heat, this property was restored, in one case, by the addition of a small amount of calcium chloride, and, in the other case, by passing a stream of carbon dioxide through the milk for half an hour. The cheeses made from the milk thus treated were left in press over night, and were then examined at once for the salt-soluble product. The determination was made as follows: An amount of the fresh cheese, weighing 25 grams, was ground with sand and extracted with several portions of distilled water at 131° F. (55° C.) until the extract amounted to 500 cc. The residue was then similarly extracted with a 5 per ct. solution of sodium chloride. The amount of nitrogen in 50 cc. of this salt extract was determined by the Kjeldahl process. Table I gives the results obtained. The figures in parenthesis indicate the serial numbers of the different cheeses.

(2) *With acid.*— Other cheeses were made exactly like the preceding, except that lactic acid was added to the milk to the extent of 0.2 per ct., by weight, of the milk. An examination of these cheeses, made at once after they were taken from press, gave the results stated in Table I.

TABLE I.—AMOUNT OF NITROGEN IN SALT-SOLUBLE EXTRACT OBTAINED FROM CHEESES MADE WITH AND WITHOUT LACTIC ACID.

	NITROGEN, EXPRESSED AS PERCENTAGE OF TOTAL NITROGEN IN CHEESE.		NITROGEN EXPRESSED AS PERCENTAGE OF CHEESE.	
	Made with addition of calcium chloride.	Made with addition of carbon dioxide.	Made with addition of calcium chloride.	Made with addition of carbon dioxide.
(1) With acid.....	27.88 (45)	29.80 (48)	0.87 (45)	0.700 (48)
With acid.....	26.62 (46)	22.90 (51)	0.84 (46)	0.754 (51)
(2) Without acid..	2.44 (44)	5.24 (49)	0.76 (44)	0.132 (49)
Without acid..	2.90 (47)	5.72 (50)	0.76 (47)	0.148 (50)

An examination of this table shows that the amount of nitrogen, in the form of the salt-soluble product, was increased very greatly by the action of the added lactic acid. The cheeses made without acid shows small amounts of this salt-soluble substance. In the case of Nos. 44 and 47, the salt-soluble product found may possibly be attributed to the slight amount of lactic acid formed in the milk before it was heated, or it may be that neutral paracasein itself is slightly soluble in salt-solution. There is some basis for this latter supposition, for, in the case of milk taken directly from a cow and immediately etherized and made into curd, these conditions excluding all possible acid formation, there still appears to be a slight solubility of the neutral paracasein in dilute salt-solution. In the case of Nos. 49 and 50 somewhat more salt-soluble product is found than in Nos. 44 and 47. This is undoubtedly due to the effect of the carbon dioxide used, even so weak an acid probably having some limited tendency to form with paracasein a salt-soluble product.

OCCURRENCES OF THE SALT-SOLUBLE PRODUCT IN NORMAL CHEESE.

In the many normal cheddar cheeses thus far examined by us, this salt-soluble substance is always found. The amounts vary, but the factors causing the variations have not been fully studied yet. For example, the amount of milk-sugar retained in the cheese is one cause of such variations; likewise those conditions affecting the quantitative conversion of milk-sugar into lactic acid. Then, again, we have not yet obtained satisfactory control of all the details of the quantitative estimation of this salt-soluble product. Its amount varies also with the age of a cheese. In cheese fresh from press, that is, about 24 hours old, we have found that from 40 to 78 per ct. of the total nitrogen is in the form of the salt-soluble substance, and the amount diminishes more or less with advance of age in the cheese, as illustrated by the figures in Table II.

TABLE II.—AMOUNT OF SALT-SOLUBLE PRODUCT IN CHEESES AT DIFFERENT AGES.

Serial number of cheese.	Age of cheese.	Salt-soluble nitrogen, expressed as percentage of total nitrogen in cheese.	Salt-soluble nitrogen, expressed as percentage of cheese.	Water-soluble nitrogen, expressed as percentage of total nitrogen in cheese.	Water-soluble nitrogen, expressed as percentage of cheese.
54	1 day.......	58.7	2.08	6.78	0.240
54	1 month	42.4	1.58	19.30	0.718
54	3 months....	33.4	1.31	26.02	1.020
31-A	2 weeks....	40.7	1.50	15.50	0.569
31-B	2 weeks....	42.8	1.58	16.50	0.608
31-C	2 weeks....	37.4	1.38	16.10	0.584
31-D	2 weeks....	40.8	1.49	15.80	0.589
38-A	3 months...	16.48	0.58	37.22	1.310
38-B	3 months...	17.60	0.63	35.48	1.270
38-C	3 months...	19.19	0.71	32.16	1.190
38-D	3 months...	21.96	0.83	29.90	1.130
38-A	9 months...	13.43	0.54	53.24	2.140
38-B	9 months...	14.29	0.57	47.75	1.910
38-C	9 months...	18.46	0.74	45.64	1.830
38-D	9 months...	18.44	0.78	40.91	1.730

An examination of Table II indicates a general tendency for the amount of nitrogen present in cheese in the form of the salt-soluble product to decrease as the cheese advances in age.

An examination of the last two columns of figures shows that, as cheese increases in age, the amount of nitrogen in the form of the water-soluble product increases. The fact that the water-soluble nitrogen in cheese increases while the salt-soluble product decreases strongly suggests that this progress in proteolysis takes place at the expense of the salt-soluble product. However, we are not inclined to assert positively that such a relation exists until we have perfected to our satisfaction the method for estimating the salt-soluble product. In cheese No. 54, one of our latest experimental cheeses, our method of extraction was under better control and the figures obtained are entirely consistent with the view that proteolysis in cheese commences with the salt-soluble product. However, the main point to which we wish to call attention in connection with Table II is that in freshly-made cheddar cheese the salt-soluble product forms a large part of the nitrogen-compounds of the cheese.

NATURE OF THE SALT-SOLUBLE PRODUCT.

(*1*) *A salt of paracasein.*— In the case of cheeses made with and without lactic acid, in the presence of chloroform, we have seen that there were large amounts of the salt-soluble product formed when lactic acid was used, and only small amounts when no acid was used. We have also seen that, in the case of normal cheddar cheeses, the salt-soluble product occurs in large proportions, increasing in quantity as the milk-sugar disappears, or, in other words, as the amount of lactic acid increases. It, therefore, appeared to us that, in this salt-soluble product, we were dealing with some compound of paracasein and lactic acid, probably a paracasein lactate.

(*2*) *Artificial preparation of paracasein lactate.*— It seemed desirable to attempt the artificial preparation of the salt-soluble product, and to ascertain if it were identical with the substance extracted by a dilute solution of sodium chloride from newly-made cheese. For the purpose of this comparison, the following experiment was undertaken in the artificial preparation of the salt-soluble product.

We coagulated about 6 liters of skim-milk by rennet at 86° F. (30° C.). The resulting curd was well washed with water, drained and then treated for one-half hour at 122° F. (50° C.) with 3 liters of a 1 per ct. solution of lactic acid. By this treatment a turbid solution was obtained, which was filtered from the large residue remaining undissolved, through cloth first and then through absorbent cotton. This filtrate, neutralized with dilute potassium hydroxide, gave a copious precipitate, which was filtered, washed with water, and redissolved in 1 liter of 0.5 per ct. solution of lactic acid. This solution was filtered and reprecipitated by dilute alkali, and the process of redissolving, filtering, and reprecipitating was repeated twice. The resulting product was finally well washed with water, suspended in 95 per ct. alcohol for 2 days and, after removal of alcohol by filtration, was extracted 24 hours with ether and dried at 212° F. (100° C.). The substance thus prepared was firm and leathery in texture, greatly resembling in physical properties the product prepared from the salt-extracts of cheese. To all ap-

pearances, the lactic acid had simply combined with the paracasein, forming a compound soluble in slight excess of acid and insoluble in neutral solutions.

(3) *Preparation of paracasein lactate obtained from cheese.*— Cheese about 3 months old was extracted with a 5 per ct. solution of sodium chloride. To 6.5 liters of this extract, lactic acid was added to the extent of 0.2 per ct. by volume, producing a flocculent precipitate that rapidly settled. The precipitate was filtered and allowed to drain in order to remove the large amount of salt adhering. The filtrate gave no further precipitate on addition of more lactic acid. The precipitate was completely soluble in 0.5 per ct. solution of lactic acid, and this acid solution gave an abundant precipitate when neutralized by dilute alkali. This neutralization precipitate was filtered, well washed with water, and then treated, in every respect, as described above in the preparation of the artificial product. In this way, 20 grams of each product were obtained.

Comparison of natural and artificial products. — The old method of comparing two products by the results of ultimate analysis, in order to establish their likeness or unlikeness, is now recognized as faulty, especially in the case of proteid bodies. Only by cleavage and by quantitative estimation of certain end-products can a reliable basis be found for determining the question of similarity of structure in different compounds.

Determinations of nitrogen, phosphorus, and ash were made in the two products. In addition, an amount of each proteid weighing 10 grams was hydrolyzed by boiling 14 hours, on a sand-bath, under a Liebig condenser, with 60 grams of water and 30 grams of sulphuric acid of sp. gr. 1.84. In the resulting liquid, ammonia and the hexon bases were determined according to the method of Kossel and Kutscher.[9] The results are given in Table III, together with similar figures obtained by Hart with casein[10] prepared directly from milk by the use of acetic acid without rennet.

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[9] *Zeit. f. Physiol. Chem.* **31**: 165 (1898).
[10] *Ibid.* **33**: 347 (1900).

TABLE III.—COMPARATIVE COMPOSITION OF NATURAL AND ARTIFICIAL PRODUCTS.

	Nitrogen Expressed as Percentage of Total Nitrogen in Form of				Nitrogen.	Phosphorus.	Ash.
	Ammonia.	Histidin.	Arginin.	Lysin.			
					Per ct.	*Per ct.*	*Per ct.*
Natural product..	7.65	2.36	7.77	2.21	15.12	0.70	1.51
Artificial product.	7.66	2.21	8.08	2.02	15.30	0.91	1.12
Casein...........	7.34	3.66	9.51	2.31	15.65	0.84	....

The results embodied in Table III indicate a striking similarity in structure between the salt formed by paracasein with lactic acid found naturally occurring in cheese and that artificially prepared, so far as the products of hydrolysis enable us to draw conclusions. This has reference simply to the linking of the nitrogen in the proteid as a whole.

Later, it will be seen that what we had really prepared in both cases was the saturated salt formed by paracasein with lactic acid and not the unsaturated salt; and, as we shall show, the unsaturated salt is the one soluble in dilute solution of sodium chloride. The formation of these combinations with acids probably does not involve any deep-seated rupture of the proteid molecule, as can readily be inferred from the results given in Table III with casein, which furnishes both saturated and unsaturated salts with acids. It is evident that, in the preparation of the artificial salt identical with the proteid extracted by common-salt solution from cheese, the chief, if not the only, active factor is an acid.

SALTS FORMED BY COMBINATION OF PARACASEIN WITH ACID.

Action of lactic acid used in different amounts upon paracasein. — In the manufacture of cheese, the lactic acid that combines with paracasein is formed by fermentation of milk-sugar, the lactic acid combining with the paracasein as rapidly as the acid is formed. It appeared desirable to study the action of lactic acid, used in different amounts, as it is formed in the fermenta-

tion process, upon paracasein under well-controlled conditions. and also to compare this action with the one taking place when pure dilute lactic acid acts upon paracasein directly without any fermentation. For this purpose it was desired to secure paracasein or cheese-curd as free as possible from acid. In order to prevent all acid fermentation, very fresh, sweet milk was treated with ether. In this way it was possible nearly to eliminate the formation of paracasein compounds of lactic acid at the beginning of the experiment and have as our original working material paracasein as nearly as possible free from salt-soluble compounds. Two analyses of paracasein, thus prepared, showed the presence of 3.90 and 4.34 per cent. of the total nitrogen in the form of a salt-soluble compound. Several bottles were prepared in the following manner: We placed in each bottle 25 grams of the carefully prepared cheese-curd or paracasein, ground with sand, and added 50 cc. of water; the mixture was thoroughly shaken, and then sterilized. To this common mixture, various additions were made in the different bottles as indicated below:

Series A received 0.5 gram of sterile milk-sugar and a pure culture of lactic-acid organism.

Series B, 1 gram of sterile milk-sugar and lactic-acid organism.

Series C, no milk-sugar and organism.

Series D, 0.5 gram of pure lactic acid and no organism.

Series E, 1 gram of pure lactic acid and no organism.

Series F, 1.5 grams of pure lactic acid and no organism.

All the bottles were kept at 60° F. (15.5° C.) and analyses were made at different periods, as indicated in Table IV.

TABLE IV.— INFLUENCE OF DIFFERENT AMOUNTS OF LACTIC ACID ON PARACASEIN.

Series.	Grams of milk-sugar used.	Age of mixture when analyzed.	Presence of milk-sugar in mixture when analyzed.	No. cc. $^{n}/_{10}$ NaOH required to neutralize 50 cc. of water extract.	Precipitate appeared on neutralizing water extract.	Nitrogen, in form of salt-soluble product, expressed as percentage of total nitrogen.
A	0.5	2 weeks..	Trace	3.9	Yes	30.36
A	0.5	2 weeks.	None	4.3	Yes	27.11
B	1.0	2 weeks.	Considerable	5.4	Yes	23.31
B	1.0	2 weeks.	Considerable	5.2	Yes	20.60
C	0	2 weeks.	None	1.2	No	3.52
C	0	2 weeks.	None	1.0	No	3.75
A	0.5	1 month.	None	4.45	Yes	40.65
A	0.5	1 month.	None	3.9	Yes	28.46
B	1.0	1 month.	Small amt..	5.2	Yes	9.76
B	1.0	1 month.	Small amt..	4.9	Yes	7.32
C	0	1 month.	None	0.6	No	3.52
C	0	1 month.	None	0.8	No	4.07
	Lactic acid.					
D	0.5	1 month.	....	3.4	Yes	44.72
E	1.0	3 months	....	6.4	Yes	2.17
F	1.5	1 month.	....	11.4	Yes	1.62

Attention is called to certain facts shown by the data embodied in this table.

1. When we used 0.5 gram of milk-sugar, the maximum amount of the product soluble in dilute solution of sodium chloride was found only after the milk-sugar had completely disappeared, as can be seen by comparing Series A at 2 weeks and 1 month.

2. When we used 1 gram of milk-sugar, the largest amount of salt-soluble product was formed, while considerable sugar was still present. As the acid fermentation of the milk-sugar continued, the amount of salt-soluble product rapidly decreased. This is shown by comparing Series B at 2 weeks and 1 month.

3. We see the same truth illustrated in Series D, E, and F, where we added pure lactic acid directly in the different quantities indicated. When we added 0.5 gram of lactic acid, there was formed a large amount of salt-soluble product, nearly 45 per ct. of the total nitrogen appearing in this form. However, when we used 1 and 1.5 grains of pure lactic acid, there was practically no salt-soluble product formed.

4. Even in the cases where the largest amounts of lactic acid were used, the acid disappeared as free acid. This was shown by making a titration of the water-extract of the curd with $\frac{n}{10}$ sodium hydroxide, using phenol-phthalein as indicator. It is readily seen that the number of cc. of alkali required for neutralization represents a very small amount of acid, compared with that furnished in Series A, B, D, E, and F. The acid had largely combined with paracasein to form products only slightly soluble in water.

The question may be raised here as to what it is in the water-extract that neutralizes alkali. In Series C it is, in all probability, direct neutralization by proteid, as no acid was present. In Series F, on the other hand, there is probably some free acid, as an excess of acid was used. In most cases, however, the neutralization is due, apparently, to a water-soluble compound of acid and proteid, as shown by the fact that only in cases where acid was furnished, whether by fermentation or by direct addition, a precipitate appeared on neutralization, and such a precipitate would be expected only in the case of a combination of acid with proteid. The larger the amount of alkali required by the water-extract for neutralization, the more abundant was the precipitate appearing on neutralization.

Just here, the main point we desire to consider is an explanation of the fact to which attention has been called above, viz.: that from a given amount of paracasein treated with a certain amount of lactic acid, we obtain a maximum yield of our salt-soluble product; while an increase of acid beyond a given amount decreases the yield of salt-soluble product. We might naturally expect that increase of acid would yield an increase of salt-soluble product from a given quantity of paracasein. How can we explain this? The explanation that agrees most satisfactorily with the experimental data at hand in this: Paracasein combines with lactic acid in at least two different proportions, forming two distinct compounds. One of these compounds is the unsaturated salt and is soluble in dilute solutions of sodium chloride; it is this compound that is present in normal cheddar cheese. The other compound is the saturated salt

formed by the combination of lactic acid with paracasein and is insoluble in dilute salt solution.

(2) *Salts formed by combination of paracasein with other acids.*— Paracasein forms salts also with other acids. Mr. A. J. Patten, has determined for us the amounts of acetic, hydrochloric, and sulphuric acids required to form the unsaturated and saturated salts. In each case, acid was added to 25 grams of fresh curd, previously ground with sand, suspended in water, and finally extracted at 122° F. (55° C.) with a 5 per ct. solution of sodium chloride.

TABLE V.— FORMATION OF COMPOUNDS BY PARACASEIN AND DIFFERENT ACIDS.

	Acetic acid.		Hydrochloric acid.			Sulphuric acid.		
Grams of acid used..........	0.5	1.0	0.15	0.25	0.50	0.15	0.25	0.50
Percentage of total nitrogen found in form of salt-soluble compound................	70.0	5.3	27.3	53.0	5.7	19.5	41.5	2.4

In this table the same general results are seen as in the case of lactic acid. A certain amount of acid forms with a given amount of paracasein a maximum quantity of salt-soluble product, and increase of acid beyond this quantity forms a compound not soluble in dilute salt-solution.

It also appears from the results given in Table V that mineral acids are required in smaller amounts than organic acids to saturate paracasein completely.

SALTS FORMED BY COMBINATION OF CASEIN WITH ACIDS.

(*1*) *Formation of unsaturated casein salt.*—We can show that casein readily forms an unsaturated and a saturated salt with an acid. In preparing the unsaturated salt, we used 5 cc. of freshly drawn milk, diluted it with 50 cc. of water, warmed the solution to 104° F. (40° C.), and then added $\frac{n}{10}$ hydrochloric acid until the resulting precipitate settled with a clear supernatant liquid, which required 2.7 cc. To this mixture we

added 2.5 grams of sodium chloride, thus making a 5 per ct. salt-solution. On warming, the unsaturated casein chloride completely dissolved. The experiment was repeated several times with a uniform result. On adding more acid to the salt-solution, the proteid reprecipitated as the saturated chloride of casein. Casein behaved toward acetic acid in the same manner.

(2) *Determination of amount of $\frac{n}{10}$ hydrochloric acid required to saturate casein.*— Fresh milk was drawn from a cow directly into a bottle containing ether, thus checking all acid fermentation. We diluted 5 cc. of this milk, containing .0261 grams of nitrogen, with 50 cc. of water that had been boiled free from all carbon dioxide. We warmed the mixture to 104° F. (40° C.) and added 10 cc. of $\frac{n}{10}$ hydrochloric acid. It was desired now to determine the amount of hydrochloric acid that had not combined with casein. Determinations of the uncombined acid did not give uniform results, when the titration was made directly after the addition of acid. We therefore employed the method of using calcium picrate.[11] We added 5 cc. of a neutral solution of calcium picrate to precipitate all proteids completely. The precipitate was filtered, and the filtrate titrated with $\frac{n}{10}$ sodium hydroxide, using rosolic acid as an indicator. The reactions taking place can be represented, theoretically, as follows:

$$\text{Casein }(OH)_2 + 3HCl\text{ (excess)} = \text{Casein }Cl_2 + 2H_2O + HCl.$$

$$\text{Casein }Cl_2 + \text{Ca picrate} + HCl = \text{Casein picrate} + CaCl_2 + HCl.$$

When calcium picrate is used, the chlorine which was combined with casein is changed into calcium chloride and, in this form, does not interfere with titration by alkali. Thus, we are able to determine more satisfactorily the amount of acid left uncombined with proteid.

In the experiment employed, it required 7.4 cc. of $\frac{n}{10}$ sodium hydroxide to neutralize the excess of acid, indicating that 2.6 cc. of acid had entered into combination with .0261 grams of proteid nitrogen. Using 6.39 as the nitrogen factor of casein, .0261 gram of nitrogen is equivalent to 0.167 gram of casein, and this amount combined with 2.6 cc. of $\frac{n}{10}$ hydrochloric

[11] Rohrer. *Archiv f. Physiol.*, 90: 368 (1902).

acid, or 1 gram of casein would require for complete saturation 15.6 cc. of $\frac{n}{10}$ hydrochloric acid. The work, repeated on 5 cc. of milk containing .031 gram of nitrogen, gave 15.9 cc. of $\frac{n}{10}$ hydrochloric acid as the amount required to saturate 1 gram of casein.

In the manner in which this work was done, it is recognized that we were dealing not with casein alone, but with the two principal proteids of milk, casein and albumin. However, there is no reason to believe that the results would be essentially different with pure casein. We shall later secure results with casein alone.

(3) *Determination of amount of $\frac{n}{10}$ hydrochloric acid required to saturate the unsaturated salt of paracasein.*— To 50 cc. of the salt-extract of some curd, containing .058 gram of nitrogen in the form of the unsaturated hydrochloric acid salt of paracasein, we added 10 cc. of $\frac{n}{10}$ hydrochloric acid for the purpose of converting the unsaturated into the saturated salt. We then added 5 cc. of neutral calcium picrate to facilitate clear filtration. The mixture was filtered, the precipitate washed, and the filtrate treated with $\frac{n}{10}$ sodium hydroxide, rosolic acid being used as indicator. Neutralization required 7.1 cc. of $\frac{n}{10}$ sodium hydroxide. Hence, to saturate the salt-soluble compound, equivalent to .058 gram of nitrogen, required 2.9 cc. $\frac{n}{10}$ hydrochloric acid. Using 6.39 as the nitrogen factor of paracasein, it required 7.83 cc. of $\frac{n}{10}$ hydrochloric acid to convert 1 gram of the unsaturated into the saturated hydrochloric acid salt of paracasein.

We saw above that it required from 15.6 to 15.9 cc. $\frac{n}{10}$ hydrochloric acid to saturate milk-casein completely, or, more strictly, casein mixed with a small amount of milk-albumin. Now, the amount of $\frac{n}{10}$ hydrochloric acid required to convert the unsaturated into the saturated hydrochloric acid salt of paracasein, 7.83 cc., is just one-half of 15.7 cc., the amount of $\frac{n}{10}$ hydrochloric acid required to form a saturated compound. Hence, the amount of combined acid in the saturated salt is twice that in the unsaturated salt; in other words, the unsaturated salt appears to be a mono-acid salt, and the saturated a di-acid salt. These results,

it is true, were obtained, in one case, with milk-casein not strictly pure and, in the other case, with the paracasein derivative of milk-casein, and it may be thought that results secured in this way do not justify the conclusion drawn in regard to the existence of two such distinct combinations of an acid with casein and paracasein. But, aside from the data presented here, there is abundant evidence that both milk-casein and paracasein form at least two salts, corresponding to a half-saturated or mono-acid salt, and a saturated or di-acid salt.

POSSIBILITY OF AN ADDITIONAL COMPOUND OF PARACASEIN WITH ACID.

There is evidence that small amounts of acid can disappear in cheese-curd without a corresponding increase of salt-soluble compound. This fact is illustrated by the following experiment: We coagulated with rennet 3 liters of freshly drawn milk, to which ether had been promptly added, and then warmed the milk to 107° F. (42° C.) in order to shrink and harden the curd. Portions of 25 grams each of this curd were ground with sand, placed in Erlenmeyer flasks, covered with 100 cc. of water, heated for 10 minutes at 185° F. (85° C.) to check completely all acid fermentation, and then treated with different amounts of lactic acid. After standing one hour, with occasional shaking, the curd in the different flasks was extracted, first with small amounts of water and then with 500 cc. of 5 per ct. solution of sodium chloride. In 50 cc. of each of these extracts, the nitrogen was determined by the Kjeldahl method. The results are given in the following table:

TABLE VI.—AMOUNTS OF SALT-SOLUBLE COMPOUND FORMED BY DIFFERENT AMOUNTS OF ACIDS.

Grams of lactic acid used..........	0	0.02	0.05	0.10	0.20	0.50
Percentage of total nitrogen in form of salt-soluble compound........	6.0	7.0	8.1	8.6	23.0	72.0

The amount of salt-soluble compound was not proportionately increased by the use of .02, .05 and .10 gram of lactic acid for 25 grams of curd; but when an additional .10 gram of lactic acid

was used, bringing the total up .20 gram of lactic acid, there was a large increase of the salt-soluble compound, and this was still greatly increased by additions of lactic acid above .20 gram up to .50 gram. It is possible that there may be formed with acids a paracasein salt containing still less acid than the half-saturated salt, or, it may be that the acid which disappears unites with some of the insoluble inorganic salts in the curd.

SOLUBILITIES OF THE SALTS FORMED BY CASEIN AND PARACASEIN WITH ACIDS.

(*1*) *Saturated salts.*— The saturated acetic and lactic acid salts of casein and paracasein, as well as the hydrochloric and sulphuric acid salts, are practically insoluble in all the media tried. They are insoluble in water; in 5 and 10 per ct. solutions of sodium chloride; slightly soluble in 50 per ct. boiling alcohol, practically insoluble at 122° F. (50° C.) in saturated solution of calcium carbonate, and in 2 per ct. solution of calcium lactate at 122° F. (50° C.). They dissolve, of course, in excess of acid or dilute alkali.

(*2*) *Unsaturated salts.*— The unsaturated or half-saturated salt of each of the acids mentioned above is insoluble in water; completely soluble in 5 per ct. solutions of sodium chloride at 130° to 140° F. (55° to 60° C.), not separating again on cooling, but entirely separating by dialysis in water; soluble in 50 per ct. boiling alcohol, but separating again on cooling; only slightly soluble in saturated solution of calcium carbonate at 122° F. (50° C.), or in 2 per ct. solution of calcium lactate.

(*3*) *Explanation of Danilewsky's error.*—Danilewsky's[12] early supposition, that casein consists of two proteid bodies separable by hot 50 per ct. alcohol, finds a reasonable explanation in the fact that the unsaturated salt formed by casein with an acid is soluble in 50 per ct. hot alcohol, while the saturated salt is insoluble in this medium. When the usual method is employed of precipitating casein from milk by means of dilute acid, the resulting product can easily be a mixture of the unsaturated and saturated salts, the quantity of each present depending

[12]*Zeit. f. Physiol. Chem.*, 7: 227 (1883).

upon the amount of acid used in the precipitation. Danilewsky, in his work, used only enough hydrochloric acid to effect a good precipitation of milk-casein and thus he formed more or less of the unsaturated salt, soluble in hot 50 per ct. alcohol. Thus, it is easy to understand how he came to the erroneous conclusion that milk-casein consists of two proteids.

(4) *Relation to Freudenreich's work.*— It will be noticed that the solubility of the two salts in solution of calcium carbonate or calcium lactate is slight. In the case of the saturated paracasein salt, it was found in one experiment that only 1.2 per ct. of the salt was soluble in saturated solution of calcium carbonate at 122° F. (50° C.) and only 1.12 per ct. was soluble in a 2 per ct. solution of calcium lactate at 122° F. (50° C.). The unsaturated paracasein salt had a solubility of 5.01 per ct. in calcium carbonate solution and 4.70 per ct. in the calcium lactate solution.

The determination of these solubilities was made in the hope of finding some explanation of the results obtained by Freudenreich[13] in his studies relating to the power of lactic-acid organisms in effecting proteolytic changes in milk-casein. Freudenreich found that sterile milk, treated with powdered calcium carbonate and then seeded with certain lactic-acid-producing bacteria, showed an increase of soluble nitrogen-compounds, in both caseoses and amides. He determined the soluble nitrogen by passing the milk through a Chamberland filter. He does not state the amount of total nitrogen in the milk at the beginning of the experiment but only the amount of soluble nitrogen. Assuming that the milk used by Freudenreich contained 0.5 per ct. of total nitrogen, the average of milk, and recalculating his results in percentages of total nitrogen, we obtain the data given in the following table:

[13] *Landw. Jahr. d. Schweiz.*, **12**: 279 (1898).

TABLE VII.—RESULTS OF FREUDENREICH CALCULATED ON BASIS OF TOTAL NITROGEN IN MILK.

AGE OF MILK WHEN ANALYZED.	Soluble nitrogen, expressed as percentage of total nitrogen in milk.	Amide nitrogen, expressed as percentage of total nitrogen in milk.	Organism used.
Beginning of experiment.	6.6	......	....
9 months.............	47.0	34.6	Milk culture Bac. ε from rennet.
13 months.............	44.4	30.2	Milk culture Bac. ε from cheese.
13 months.............	49.2	......	Milk culture Bac. ε from cheese.
14 months.............	42.8	28.0	Bac. *a* and Bac. ς.
9 months.............	18.8	10.6	Bac. *a*.

The amounts of soluble nitrogen reported by Freudenreich as being formed by the action of different lactic-acid-producing organisms are considerable. Moreover, it is to be noticed that quite large amounts of amide nitrogen are formed. While there were in the flasks used solutions of calcium carbonate and of calcium lactate, we can not explain the relatively large amounts of soluble nitrogen by the solubility of either the saturated or unsaturated lactates of casein in solution of calcium carbonate or lactate. Whether his explanation is correct or another is to be found, Freudenreich's results clearly represent actual proteolytic changes of casein.

Nicholson[14] repeated Freudenreich's work, using the common lactic acid bacterium found in cheese, but failed to find any proteolysis of casein. Nicholson says: "In some cases, the table shows a slight increase in soluble nitrogen, where the calcium carbonate has been added; in others, there is no increase. In the uncarbonated milk there is absolutely no increase in any case." The slight increase reported by Nicholson in the case of the milk containing calcium carbonate can readily be explained on the basis of the slight solubility of the lactic-acid salts of casein in solution of calcium carbonate or calcium lactate.

We have recalculated a portion of Nicholson's results on the same basis as that used with Freudenreich's figures, and give them in the table following.

[14] Thesis for Master's Degree—Univ. of Wis. 1902.

TABLE VIII.— RESULTS OF NICHOLSON'S WORK WITH LACTIC ACID BACTERIA.

Without Calcium Carbonate.			With Calcium Carbonate.		
Age of milk when analyzed.	Soluble nitrogen, expressed as percentage of total nitrogen in milk.	Amide nitrogen, expressed as percentage of total nitrogen in milk.	Age of milk when analyzed.	Soluble nitrogen, expressed as percentage of total nitrogen in milk.	Amide nitrogen, expressed as percentage of total nitrogen in milk.
0	8.8	3.8	0	9.6	4.0
0	9.2	3.6	0	9.8	4.0
59 days	13.2	3.2	28 days	18.0	4.0
59 days	12.6	3.0	28 days	21.8	2.8
450 days	10.2	1.4	257 days	12.6	2.2
450 days	8.4	trace	257 days	12.2	trace
....	....	....	314 days	13.2	2.8
....	....	....	314 days	12.0	3.2
....	....	....	450 days	12.6	trace
....	....	....	450 days	14.0	trace

In some of our future work bearing more directly upon the chemical changes taking place during the process of cheese-ripening, we shall have occasion to refer to this subject again.

RELATION OF THE UNSATURATED PARACASEIN LACTATE TO THE CHEDDAR PROCESS OF CHEESE-MAKING.

As previously stated, it has been supposed that the presence of lactic acid was, in some way or other, responsible for, or associated with, some of the most important changes taking place in the curd during the cheese-making process, such as the acquired ability to form strings on a hot iron and the change in appearance and plasticity of curd; but no one has previously been able to show beyond question that these changes were actually brought about by an acid, or in what way they were accomplished. We purpose now to show the intimate relation existing between the presence of unsaturated paracasein lactate and some of the important changes occuring in the curd during the process of making cheese.

(1) Property of curd to string on hot iron due to unsaturated casein lactate.—We coagulated by rennet about 27 liters of milk, properly ripened for cheese-making, and carried on the process

of treatment in the usual normal manner employed in manufacture. At different intervals, samples of curd were taken in order to determine the amount of salt-soluble compound present; also, samples of whey were taken at the same time for the purpose of determining the amount of milk-sugar. The changes took place rather slowly in this instance, owing to the fact that the milk was more than usually sweet for cheese-making purposes; that is, it was so fresh as to contain only small amounts of lactic acid at the start.

We present here our results in tabular form.

TABLE IX.— INCREASE OF SALT-SOLUBLE COMPOUND IN CURD WITH DECREASE OF MILK-SUGAR IN WHEY.

Time of taking sample of curd.	Percentage of total nitrogen in form of salt-soluble compound.	Percentage of milk-sugar in whey.	Remarks.
Rennet added at 9.30 a. m.			
10 o'clock a.m.	5.0	4.75	Curd did not string.
12 o'clock m.......	6.1	....	Curd just began to string. Whey removed from curd.
4 o'clock p. m....	31.7	1.83	Curd formed strings 1 inch long. Curd put in press.

The results in this table show that as the amount of salt-soluble compound present in the curd increased, the curd acquired the property of forming longer strings on the hot iron. That this was due to the increase of salt-soluble compound is confirmed by the fact that the unsaturated salt of casein lactate itself, when isolated from curd or cheese, forms on hot iron beautiful, fine, silky threads, of almost any length desired. The same is true also of the product artificially prepared.

(2) *"Breaking-down" process in curd due to formation of unsaturated paracasein lactate.*—After the whey is removed from the curd in the process of cheese-making, the curd is "packed" or "matted," that is, piled in a heap, and kept in this condition, with occasional repacking, until it has gone through the regular

"breaking-down" process, in the course of which the curd undergoes several marked, easily discernible changes in physical properties. From a tough, rubber-like consistency, with a high water-content, the curd changes to a mass having a smooth, velvety appearance and feeling, and a softer, somewhat plastic consistency. The texture also changes so that the curd acquires a peculiar kind of grain and tears off somewhat like the cooked meat of a chicken's breast.

These marked changes in the physical properties of the curd can be most readily and satisfactorily explained by attributing them to the increasing quantity of the unsaturated casein lactate produced throughout the cheese mass, as the result of continuous formation of lactic acid by the fermentation of the milk-sugar present. These changes in the properties of curd take place simultaneously with the formation of unsaturated casein lactate and do not take place in the absence of this compound. The softening of curd, or "breaking-down" process, is attributed by Duclaux to the action of vibrios, but this is certainly an error so far as relates to American cheddar cheese.

(3) *Abnormal softening of curd on addition of salt, due to the presence of the unsaturated paracasein lactate.*— It sometimes happens that, when curd is salted, it softens remarkably, appears to be slimy, and slips through the fingers when squeezed in the hand. This is a condition which has not been satisfactorily explained; the usual explanation is that liquefying organisms have prevailed over all others and have dissolved some of the curd. The real explanation is as follows: When curd behaves, on salting, in the manner described above, more than the usual amount of lactic acid has been formed, and, hence, more than the usual proportion of unsaturated paracasein lactate has resulted. When salt is added to such curd, we at once have a brine formed, which is capable of dissolving the unsaturated paracasein lactate contained in the curd, thus producing a pasty, soft, slippery mass.

In an experiment in which we made cheese from pasteurized milk, we endeavored to simulate the action of lactic acid, as formed by fermentation in ordinary cheese-making, by substitut-

ing in its place hydrochloric acid, added in small quantities from time to time, both before and after the addition of rennet. Paracasein chloride was readily formed by the curd, but the use of somewhat too much acid produced an abnormally large proportion of the unsaturated salt, which, on addition of common salt, formed a mushy, slippery mass. The curd, in this condition, was suspended in water and more hydrochloric acid was added, resulting in the production of a firm, exceedingly hard curd, due to the conversion of unsaturated into saturated paracasein chloride, the latter compound not being soluble in salt-solution.

(4) *Amount of unsaturated paracasein lactate in newly-made cheese.*— In new cheese, fresh from press, prepared under normal conditions, we have found as much as 78.5 per ct. of the nitrogen-compounds present in the form of unsaturated paracasein lactate. The proportions of this compound in new cheese depend upon a variety of conditions, which we are engaged in studying. It appears probable that, in the case of normal, newly-made cheese, the nitrogen-compounds consist mainly of unchanged paracasein and unsaturated paracasein lactate, the latter compound being present in large proportions. Saturated paracasein lactate probably does not occur in normal cheese, but only in cheese made with excessive acid, as, for instance, cheese made from sour milk.

RELATION OF UNSATURATED PARACASEIN LACTATE TO CHEESE-RIPENING.

As cheese ages, it undergoes various changes, passing from an insoluble and flavorless substance into the palatable, more easily digestible, and nutritious material we use as food. The term "ripening" is applied to the general process that embraces these changes. Among the most extensive and profound changes occurring in cheese-ripening are those experienced by the nitrogen-compounds of the newly-made cheese, chief of which is unsaturated paracasein lactate.

A large amount of bacteriological and chemical work has been done in order to ascertain the cause of the changes that occur in the nitrogen-compounds during the ripening of cheese. All of

this work has assumed that paracasein formed the primary point of attack or starting point in these changes. Our results, presented in the foregoing pages, suggest that unsaturated paracasein lactate, and not paracasein, is the real material with which the process of cheese-ripening commences. It is not our purpose, at this time, to go into the subject in more than a preliminary way. In connection with Table II, p. 174, attention has been called to the fact that the amount of water-soluble nitrogen in cheese, which is a general measure of the extent of cheese-ripening, increases at the same time that the unsaturated paracasein lactate decreases, and probably at the expense of the latter compound.

The belief that the proteolytic changes of cheese-ripening actually start with the unsaturated paracasein lactate receives confirmatory evidence from the fact that, in the absence of unsaturated paracasein lactate in cheese, we have very incomplete proteolytic change. In order to establish beyond question the specific relation of unsaturated paracasein lactate to the proteolytic changes of cheese-ripening, we have under way numerous experiments in which preparations of pure unsaturated paracasein lactate are being subjected to the action of a variety of agencies, such as different enzymes and organisms that have been commonly associated with the different theories of cheese-ripening.

Some results, already secured, appear to indicate that the first proteolytic changes in cheese-ripening are the result of peptic digestion of unsaturated paracasein lactate. In cheese, pepsin appears to act, not to any marked extent upon the proteid paracasein, but only upon its unsaturated compounds with acids. Hence, the function of an acid in cheese-making is the production of an unsaturated compound of paracasein with acid. This suggests that something of the same kind of action may be found to be true in the case of gastric digestion. It is well established that pepsin acts upon proteids in the stomach only in the presence of dilute acid. The function of the hydrochloric acid of the gastric juice, like lactic acid in cheese, may be the formation of compounds with proteids; in other words, it may be found that pep-

sin in gastric digestion does not act upon pure proteids but only upon their compounds with acids, in this case hydrochloric acid. While this general view has been held for some time, there have not, so far as we know, been any actual experiments previously made in testing the action of pepsin upon pure compounds formed by proteids with acids. We have done this only in the case of the unsaturated paracasein lactate, but this appears as the first instance to furnish proof in an individual case of what may be found true, in general, of all cases of peptic digestion.

METHODS FOR THE ESTIMATION OF THE PROTEOLYTIC COMPOUNDS CONTAINED IN CHEESE AND MILK.*

L. L. Van Slyke and E. B. Hart.

INTRODUCTION.

When milk-casein and its salts, or paracasein in cheese and its salts, are acted upon by dilute acids or alkalies under certain conditions or by enzymes or by micro-organisms, the proteid bodies are split up, forming a variety of complex cleavage products. The extent and intensity of such proteolytic changes are measured by the proportions and kinds of the different compounds resulting from the decomposition. In the ripening process that takes place in cheese, we have an instance of extensive proteolysis in the case of the nitrogen compounds of the fresh cheese, due probably to the combined action of dilute acid, enzymes and micro-organisms. In our study of the causes that produce cheese-ripening and of the conditions that influence the process, we were, at the start, brought face to face with the difficulty involved in the lack of satisfactory methods for making quantitative separations and determinations of the products of cleavage formed. While we have well elaborated methods for estimating the amount of casein and albumin in fresh milk, these are of little aid in studying the products of their decomposition. Little attention has been given to the development of methods that are applicable to the products occurring in this field. Serious difficulties are involved in such a study. First, we know at present only in an extremely meagre and vague way the chemical constitution of milk-casein and its allied compounds. As regards the constitution of the various compounds formed by the proteolysis

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of casein, we are largely in the dark, except in the case of some of the simpler ones. In the second place, this field is difficult to study, because the quantities of individual compounds that we have to work with are usually very small. Under these conditions, methods of quantitative separation must, at best, be regarded as largely empirical and more or less tentative. Instead of estimating individual compounds, about which our chemical knowledge is complete, we are compelled, in a large degree, to estimate groups of compounds, the individual members of which we know, for the most part, incompletely, or not at all.

From the peptic digestion of casein, Chittenden has separated the proto- and deutero-caseoses,[1] and, from a tryptic digestion, a deutero-caseose and a peptone.[2] Alexander[3] has separated hetero-caseose from a peptic digestion of casein, but only in small quantities. Many investigators have observed paranuclein or pseudonuclein, the insoluble residue remaining from the peptic digestion of casein or paracasein. Emil Fischer and P. A. Lavene[4] have obtained pyrrolidine-α-carbonic acid from a tryptic digestion of casein.

By hydrolysis of casein with hydrochloric acid, Cohn[5] obtained l-parahydroxyphenyl-α-amidopropionic acid (tyrosine), l-α-amidoisobutylacetic acid (leucine), amidosuccinic (aspartic) acid, α-amidoglutaric (glutamic) acid, a pyridine derivative, and ammonia; by the same means, Emil Fischer[6] has recently isolated, among the monoamido acids, in addition to products previously obtained by others, amidovaleric acid, phenyl-α-amidopropionic acid (phenylalanine), pyrrolidine-α-carbonic acid, and probably amido-acetic acid (glycocoll).

Among the crystallizable end-products which have been found in ripening cheese are the following: Tyrosine, leucine, histidine, *a,* -diamidocaproic acid (lysine), tetramethylenediamine (putrescine), pentamethylenediamine (cadaverine), lysatine, guanidine probably, and ammonia. Most of these products have been

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[1]Studies in Physiol. Chem. Yale Univ., **2**: 156 (1884–5).
[2]Studies in Physiol. Chem. Yale Univ., **3**: 66 (1887–8).
[3]*Zeit. f. Physiol. Chem.*, **25**: 411 (1898).
[4]*Zeit. f. Physiol. Chem.*, **33**: 170 (1901).
[5]*Ber. deut. Chem. Ges.*, **29**: 1785 (1896).
[6]*Zeit. f. Physiol. Chem.*, **33**: 151 (1901).

recently reported by Winterstein and Thöny[7] as being found in emmenthaler cheese. Excepting cadaverine and guanidine, they had also been previously found, though not reported, in American cheddar cheese in this laboratory. It is very probable that other amido compounds will be found sooner or later, among the products formed by the tryptic, if not the peptic, digestion of milk-casein and of cheddar cheese.

In cheese we find, earlier or later, during the ripening process a series of compounds and groups of compounds, which, so far as we know at present, appear in something like the following order of succession: (1) Paracasein, (2) unsaturated paracasein lactate, (3) paranuclein (pseudonuclein), (4) caseoses (albumoses), (5) peptones, (6) amido-acid compounds, and (7) ammonia. After the early stages of ripening, we have present at the same time all these different compounds and groups.

We will consider methods for the separation and estimation of the proteolytic products found, first in cheese, and, second, in milk, following the general order indicated above. It may be well to say at the outset that, in dealing with the separation of nitrogenous bodies so complex in composition as those mentioned above and occurring in very variable quantities, we can, in the study of milk and cheese problems, hope, at present, only to approximate accurate quantitative results. While we have in the Nencki method a very accurate means of estimating ammonia, the methods used in separating peptones from amido compounds can not be relied upon to give us more than approximate results.

I. METHODS FOR THE SEPARATION AND ESTIMATION OF THE NITROGEN COMPOUNDS OF CHEESE.

We will present our description and discussion of the methods used for the separation and estimation of the nitrogen compounds of cheese in the following order:

1. Obtaining sample.
2. Determination of total nitrogen in cheese.
3. Extraction of water-soluble products.

[7] *Zeit. f. Phys. Chem.*, **36**: 28 (1902).

4. Determination of total water-soluble nitrogen.

5. Determination of nitrogen in the form of paranuclein.

6. Determination of nitrogen in the form of proteids coagulable by heat in neutral solution.

7. Determination of nitrogen in the form of caseoses (albumoses).

8. Determination of nitrogen in the form of amido-acid compounds.

9. Determination of nitrogen in the form of peptones.

10. Determination of nitrogen in the form of ammonia.

11. Determination of nitrogen in the form of unsaturated paracasein lactate.

1. OBTAINING SAMPLE OF CHEESE.

A sample of cheese is obtained for analysis by means of a cheese-trier, which enables one to secure a round plug of cheese about half an inch in diameter and four to six inches long. Four or five plugs are drawn, one within a short distance of the center of the cheese, one about an inch from the outer circumference, and the others at points equidistant between the two previous ones taken. Samples thus taken represent practically all different conditions existing in the cheese. After each plug of cheese is removed, about an inch of the end having the rind is cut off and the rest placed in a well-stoppered, large-mouthed sample-bottle. The end with the rind is dipped once or twice in melted paraffin and then carefully replaced in the cheese, being pushed in a little below the surface. After all the plugs have been taken and the ends properly replaced in the cheese, some of the melted paraffin is poured over the surface to fill up and surround the depressions made by replacing the ends of the plugs. This treatment generally insures the exclusion of mold and prevents abnormal loss of moisture in the portions of cheese near the holes left by the removal of the cheese plugs. This is a matter of much importance, when one intends to keep the same cheese for one or two years for systematic examination.

When one has taken all the plugs of cheese needed, the analysis should not be long delayed. The cheese in the bottle

is cut into small pieces with a spatula and stirred within the bottle, in order to mix the whole into as homogeneous a mass as possible.

2. DETERMINATION OF TOTAL NITROGEN IN CHEESE.

We weigh out 1 or 2 grams of the cheese, prepared as described above, for the determination of the total nitrogen and treat it according to the Kjeldahl-Gunning method, modified as follows: When the solution has become partially digested, we add a piece of copper sulphate about as large as an ordinary pea. Unless this is done, it will take a long time to convert the organic nitrogen completely into ammonia.

3. EXTRACTION OF WATER-SOLUBLE PRODUCTS.

In a porcelain mortar we thoroughly mix 25 grams of our cheese sample, prepared as indicated above, with about an equal bulk of clean quartz sand. This mixture is transferred to a 450 cc. Erlenmeyer flask, to which we add about 100 cc. of distilled water at a temperature of 50° C. The flask is then placed on a water bath or in some place where it can be kept at a temperature of 122° F. to 131° F. (50° C. to 55° C.), and is allowed to stand for half an hour, being vigorously shaken from time to time. The liquid portion is then decanted through a filter of absorbent cotton into a 500 cc. flask. The residue is again treated with 100 cc. of water, heated, agitated, and the liquid decanted as before. This process is repeated, until the filtrate after being cooled to room temperature, amounts to 500 cc., exclusive of the fat, which usually is present at the top of the liquid.

The cotton filter mentioned is made of two layers of absorbent cotton prepared as follows: In a glass funnel we place some absorbent cotton to the depth of about one inch, moisten this with water, in order to compact it, and then above this place another layer of cotton of the same thickness. Upon this we pour our portions of cheese extract. This kind of filter allows rapid filtration without the aid of a pump, and is as effective in every way as paper, which requires half a day

or more for complete filtration of 500 cc. of extract. Several samples of cheese can be extracted at the same time. The upper layer of cotton holds all solid particles and can be returned to the flask for extraction with salt-solution.

The method of making a water-extract of cheese, as described above, insures the complete removal of all water-soluble nitrogen compounds present in the cheese without danger of coagulating any soluble proteids. The use of water at room temperatures is not, in our experience, equally effective in making a complete extraction of the water-soluble products. Under some conditions, as in the early stages of ripening cheese at low temperatures, small amounts of a body are extracted by water which is precipitated by heat in neutral solution. We are unable to say at present whether this body consists of acid salts of paracasein or of hetero-caseose, which are practically insoluble in water, or whether it is some other compound. The temperature 122° F. (50° C.) also has the advantage of arresting further peptic or trypic action during the extraction. The use of acids in extracting cheese is to be avoided, since a small amount of acid will not only precipitate the soluble nuclein but may form salts with paracasein, which are somewhat soluble in a slightly acid solution; the amount of dissolved paracasein salts under such circumstances depends on the amount of acid used and the time of extraction.

4. DETERMINATION OF TOTAL WATER-SOLUBLE NITROGEN.

For the determination of the amount of total water-soluble nitrogen, we take 50 cc. of the water-extract, prepared as described above, equivalent to 2.5 grams of cheese, and treat it according to the Kjeldahl method for determining nitrogen.

5. DETERMINATION OF NITROGEN IN THE FORM OF PARANUCLEIN (PSEUDONUCLEIN.)

To 100 cc. of the water-extract, equivalent to 5 grams of cheese, we add 5 cc. of a 1 per ct. solution of hydrochloric acid, and warm the mixture on the water-bath at 122° F. to 131° F. (50° C. to 55° C), until complete separation takes place, as shown by a

clear supernatant liquid. The preciptate is filtered, washed with water, and then, with the filter paper, treated by the Kjeldahl method to determine the amount of nitrogen. The nitrogen equals nitrogen present in the form of paranuclein (pseudonuclein).

In our early work we used 2 or 3 cc. of a saturated alum solution for this determination, for the reason that, in the separation of casein in milk, we had used this reagent successfully; but at the time we did not know the nature of the body we were precipitating from our water-solution of cheese. Later, when we had studied it and learned its character, we found, on comparing precipitations by use of alum and by hydrochloric acid, that alum gave high results, undoubtedly precipitating some caseoses. In 27 comparative trials with water-extracts of different cheeses, we found in the alum precipitate nitrogen varying from 0.2 to 0.337 per ct. of the cheese and averaging 0.269 per ct., while the nitrogen in the hydrochloric acid precipitate varied from 0.046 to 0.145 per ct. of the cheese and averaged 0.085 per ct. The nitrogen precipitated by alum in these 27 cases was from 2.1 to 5.5 times as much as that precipitated by hydrochloric acid, the average of all being 3.2. Since hydrochloric acid is known to precipitate paranuclein completely, we are justified in assuming that the alum precipitates other compounds, and this is confirmed by other work, showing that when alum is used as the first precipitant, we get smaller quantities of caseoses in the filtrate than we do when we use hydrochloric acid as the precipitant of paranuclein. Alum appears to resemble zinc sulphate as a precipitant of proteids.

Paranuclein (pseudonuclein) results from the breaking down of casein or paracasein and is always found in the water-extracts of ripening cheese, whether salted or unsalted. It may, perhaps, be regarded more accurately as a residue, and probably should not be counted as one of the products to be used in measuring the extent of cheese-ripening. This is undoubtedly the same body as Chittenden's dyspeptone,[8] which he found as an insoluble residue in a pepsin-hydrochloric-acid digestion of casein.

[8]Studies in Physiol. Chem. Yale Univ., 3: 66 (1887–8).

6. DETERMINATION OF NITROGEN IN THE FORM OF PROTEIDS COAGULABLE BY HEAT IN NEUTRAL SOLUTION.

The filtrate from the preceding determination (5) is made neutral with dilute caustic potash, using phenolphthalein as an indicator. It is then heated at the temperature of boiling water, until any coagulum that forms settles completely, leaving a clear supernatant liquid. The precipitate is washed with water and its nitrogen determined by the Kjeldahl method. In our experience such a precipitate rarely occurs, except in the case of cheese ripened near freezing point. The nature of this body we have not yet investigated.

7. DETERMINATION OF NITROGEN IN THE FORM OF CASEOSES (ALBUMOSES.)

The filtrate from the preceding determination (6) is treated with 1 cc. of 50 per ct. sulphuric acid, saturated with c. p. zinc sulphate and then warmed to about 158° F. (70° C.), until the caseoses separate completely and settle. The mixture is allowed to cool and is then filtered. If filtered hot, there will occur a further separation of caseoses in the filtrate on cooling. The precipitate is washed with a saturated solution of zinc sulphate made slightly acid with sulphuric acid. The nitrogen in the precipitate is determined by the Kjeldahl method.

For the determination of caseoses the use of ammonium sulphate was exclusively employed, until Bömer[9] proposed the use of zinc sulphate, which possesses a distinct advantage in enabling one to determine nitrogen directly in the precipitate or filtrate. This method has been employed in the estimation of caseoses also by the Wisconsin Agricultural Experiment Station. In the present state of our knowledge of this class of compounds, zinc sulphate must be regarded as the most available reagent for their quantitative separation.

8. DETERMINATION OF NITROGEN IN THE FORM OF AMIDO-ACID COMPOUNDS.

The amido-acid compounds are determined in the filtrate from the precipitation of peptones (9). For the removal of peptones three reagents have been commonly used —(1) Tannin and

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[9] *Zeit. f. Analyt. Chem.*, 5: 562 (1895).

sodium chloride, (2) phosphotungstic acid with sulphuric acid, and (3) bromine with hydrochloric acid. After the removal of peptones, the filtrate contains amido-acid and ammonia compounds. After determining the amount of total nitrogen in this filtrate and then the amount of nitrogen present in the form of ammonia, as obtained in 10, p. 211, we subtract the amount of ammonia nitrogen from the combined amount of amido-acid and ammonia nitrogen and thus obtain the amount of amido-acid nitrogen. In the following section (9) we describe the methods involved in removing peptones by the different reagents, and the efficiency of each reagent.

9. DETERMINATION OF NITROGEN IN THE FORM OF PEPTONES.

(1) By tannin and sodium chloride.—We place 100 cc. of our water-extract of cheese in a 250 cc. graduated flask, add 1 gram of sodium chloride and a solution containing 12 per ct. of tannin, until one drop added to the clear supernatant liquid gives no further precipitate. We then dilute to the 250 cc. mark, shake, filter through a dry filter and determine the amount of nitrogen in 50 cc. of the filtrate by the Kjeldahl method; this gives us the amount of nitrogen in the form of amido-acid and ammonia compounds. The amount of nitrogen in the form of peptones is determined by difference, that is, by subtracting from the amount of total nitrogen in the water-extract the combined sum of the amounts of nitrogen found in 5, 6, 7, 8 and 10.

The combination of tannin and salt has been settled upon by us as the most satisfactory for the separation of casein-derived peptones from amido-acid compounds in milk and cheese analysis, when, as is commonly the case, we have large amounts of amido-acid compounds relative to peptones. We have confirmed Schjerning's[10] results showing that this reagent does not precipitate the monoamido-acid compounds, such as leucine, tyrosine, aspartic acid, glumatic acid and amidovaleric acid, nor does it precipitate histidine, arginine, lysine, cadaverine, putrescine, lysatine or ammonia. In our work the tannin-salt solution has nearly as great a precipitating power as phosphotungstic acid, precipitating 93.3 per ct. of the total nitrogen compounds

[10] *Zeit. f. Analyt. Chem.*, **39**: 545 (1900).

present in a sample of fresh milk; in a study of ripened cheese, it precipitated the uncrystallizable end-products, caseoses and peptones, so completely that no further trouble was experienced in separating the crystallizable end-products.

It is well to record the fact here that, when precipitation of peptones with tannin-salt solution is attempted in a mineral acid solution, no precipitate occurs; it is only in neutral solution that more complete precipitation takes place.

The chief objection to the use of tannin-salt solution as a means of separating caseoses and peptones from amido-acid compounds and ammonia is that it is not a complete precipitant of peptones. Hence, when we use the reagent for this separation, we commonly leave some peptones to be estimated as amido-acid compounds, the amount of peptones thus being made smaller, and the amount of amido-acid compounds larger, than the quantity actually present. Under our discussion of the use of phosphotungstic acid as a reagent for separating these classes of nitrogen compounds, we will give for comparison some results secured by each of the two reagents.

(2) *By phosphotungstic acid with sulphuric acid.*— In a 250 cc. graduated flask we place 100 cc. of the water-extract of cheese, add 100 cc. of water and then 5 cc. of strong sulphuric acid. To this we add phosphotungstic acid of 30 per ct. strength until one drop gives no further precipitation in the clear supernatant liquid. We then dilute to the 250 cc. mark and filter through a dry filter. In 50 cc. or 100 cc. of this filtrate we determine the amount of nitrogen by the Kjeldahl method and then the amount of peptones is obtained by difference.

Phosphotungstic acid has come into very general use in this country and in Europe as a means of separating peptones from amido-acid compounds in work with cheese and milk. The work of Stutzer[11] and of Bondzynski[12] agrees in showing that phosphotungstic acid is a complete precipitant of casein, caseoses and peptones, while in their experience it does not precipitate the amido-acid compounds or ammonia. Freudenreich and Jensen in all their work, even of recent date, have used this reagent in

[11] *Zeit. f. Analyt. Chem.*, **35:** 493 (1896).
[12] *Landw. Jahrbuch der Schweiz* (1894).

the cold as a means of separating peptones from amido-acid compounds. Babcock, Russell and Vivian in this country have used it, as well as tannin, designating the different precipitates as "peptones by phosphotungstic acid" and "peptones by tannin."

In the introductory portion of this paper, when mentioning different cleavage products of casein, we included among them the hexon bases, viz: arginine, histidine, and lysine, and, in addition, certain compounds resulting from their cleavage, such as putrescine and cadaverine, and also pyrrolidine-α- carbonic acid, all of which are precipitated by phosphotungstic acid. While all these products have not been separated from ripening cheese, it is probable that they will be sooner or later. We shall soon publish results of work done in this laboratory showing in normal ripening cheese the presence of histidine, lysine, putrescine (derived from arginine)[13] and Siegfried's lysatine, which is also precipitable by phosphotungstic acid. The quantities of these bases that can be derived from casein are not to be neglected, since, for example, in the hydrochloric-acid cleavage 15.4 per ct. of the nitrogen of the products splits off into the hexon bases. Bondzynski has used phosphotungstic acid in hot solution with arginine and finds the precipitate soluble when hot, separating out on cooling, and this statement we can confirm, the solution, however, being complete only on boiling. In the case of lysine, histidine, and putrescine, the phosphotungstic acid precipitate fails to redissolve completely at the temperature of the water-bath or on boiling. This behavior renders worthless the use of phosphotungstic acid as a reagent for the separation of peptones from those amido-acid compounds that are precipitated by it.

We have seen that tannin-salt solution fails to precipitate peptones completely and that phosphotungstic acid precipitates, in addition to peptones, some amido-acid compounds. When, therefore, we use these two reagents in precipitating solutions that contain both peptones and amido-acid compounds, as in the case of normal ripening cheese, we should expect to find the amount of nitrogen compounds left in the filtrate less with phos-

[13]A. Ellinger. *Ber. deut. chem. Ges.*, **31**: III: 383 (1898).

photungstic acid than with tannin. This is found invariably to be the case. Vivian[14] has published some results obtained with nine different cheeses which illustrate this point. We give his figures in the table following:

TABLE I. — COMPARISON OF PHOSPHOTUNGSTIC ACID AND TANNIN-SALT SOLUTION IN PRECIPITATING THE NITROGEN COMPOUNDS CONTAINED IN WATER-EXTRACTS OF CHEESE.

	PERCENTAGE OF NITROGEN IN CHEESE FOUND IN FILTRATES AFTER PRECIPITATION BY—									
No. of sample	1	2	3	4	5	6	7	8	9	Ave.
Phosphotungstic acid	1.08	1.00	0.82	0.63	0.67	1.69	0.95	1.10	1.22	1.02
Tannin-salt solution	1.54	1.26	1.12	0.65	1.16	1.87	1.08	1.36	1.42	1.27

In connection with the above results, nothing was stated in regard to the history of the cheeses used in the work. We have been able to study the action of phosphotungstic acid and tannin-salt solution in connection with samples of cheese that were under known well-controlled conditions, enabling us to know something of the general character of the proteolytic changes taking place. We placed 25 grams of cheese curd in each of several Erlenmeyer flasks, added 50 cc. of water and sterilized the contents by heat. We then added .5 gram of concentrated lactic acid, in order to convert the paracasein into unsaturated paracasein lactate.[15] To some of the flasks thus prepared we added sterilized pepsin, and to others sterilized rennet-extract. For this purpose the enzymes were prepared as follows: We dissolved 600 milligrams of Parke, Davis & Co.'s aseptic pepsin in 25 cc. of water, added 0.5 per ct. of formalin (containing 40 per ct. of formaldehyde), and let the solution stand until bacteriological examinations, made by Mr. H. A. Harding, showed the absence of living organisms. The mixture was then diluted to 100 cc. with water, and to each flask containing cheese we added 10 cc. of this sterilized pepsin solution. One thousand parts of the mixture in each flask thus contained one part of pepsin.

[14] Ann. Rept. Wis. Exp. Sta., 16: 171 (1899).
[15] N. Y. Agr. Exp. Sta. Bul. No. 214:67 (1902).

In preparing the sterilized rennet solution, we diluted 5 cc. of Hansen's rennet-extract to 25 cc. with water, added 5 per ct. of formalin, proved the completeness of sterilization by bacteriological examinations, diluted to 100 cc. and added 10 cc. of this preparation to each flask containing cheese.

The flasks thus prepared were kept at 60° F. (15.5° C.). The analytical results given below were obtained at the end of two and four weeks. In this work we had only the enzymes of pepsin and of rennet-pepsin acting upon our proteid. Under these conditions, especially in the given length of time, we should not expect the formation of any considerable amount of amido-acid compounds precipitable by phosphotungstic acid. The results obtained are given in the following table:

TABLE II.—COMPARISON OF PHOSPHOTUNGSTIC ACID AND TANNIN-SALT SOLUTION IN PRECIPITATING THE NITROGEN COMPOUNDS FORMED BY PEPTIC DIGESTION OF CHEESE.

	PERCENTAGE OF NITROGEN IN CHEESE FOUND IN FILTRATE AFTER PRECIPITATION BY—								
No. of sample	1	2	3	4	5	6	7	8	Ave.
Phosphotungstic acid	0.10	0.10	0.150	0.175	0.10	0.08	0.16	0.16	0.128
Tannin-salt solution	0.45	0.44	0.645	0.685	0.48	0.46	0.73	0.70	0.574

In every case except one the amount of nitrogen not precipitated by tannin-salt solution was more than four times the amount obtained by phosphotungstic acid. No ammonia was present in any case. In view of these widely differing results in relation to the amounts of amido-acid compounds found, the questions may be asked: Which reagent more nearly represents the amount of amido compounds actually present? Does the tannin-salt reagent fail to precipitate the peptones completely, thus allowing the unprecipitated peptones to be counted among the amido-acid compounds? Or does the amount of nitrogen in the filtrate in case of this reagent really represent amido-acid compounds? Does the phosphotungstic acid precipitate some of the amido-acid compounds simultaneously with

the peptones, thus cutting out a part of the amido-acid compounds and counting that part among the peptones? Or is there in the cheese only the small amount of end-products indicated by the action of the phosphotungstic acid?

While we did not by individual isolation determine to what extent amido compounds were present, we are justified in believing that such compounds were not yet present in the cheese in any appreciable degree; and, hence, the figures obtained with phosphotungstic acid are much nearer the truth than those obtained by tannin-salt precipitation. We will state our reasons for this belief. The amido compounds precipitated by phosphotungstic acid are known to be chiefly the diamido compounds, while the monoamido compounds are precipitated little, if at all. Hence, the compounds found in the filtrate of a phosphotungstic acid precipitation are mainly monoamido compounds. Now let us assume temporarily that the amounts of nitrogen in the tannin-salt filtrate, given in the table above, represent the total amido compounds, free from peptones; then, since the monoamido compounds are represented by the amounts of nitrogen obtained in the phosphotungstic acid filtrate, the difference between the two sets of figures, that is, those obtained by tannin-salt solution and those obtained by phosphotungstic acid, represents the amount of diamido compounds. Taking the average of the results given in the table above, the nitrogen of the total amido compounds is 0.574 per ct. of the cheese, while the nitrogen of the monoamido compounds is 0.128 per ct. of the cheese, thus leaving the difference as the nitrogen of the diamido compounds equivalent to 0.446 per ct. of the cheese. According to these figures, the monoamido compounds constitute about 22 per ct. of the entire amount of amido bodies, while the remainder, 78 per ct., represents largely diamido compounds. In this case, the ratio of monoamido to diamido compounds is as 1 to 3.5. Keeping these data in mind, we will call attention to some work done by Hart[16] in studying the cleavage end-products formed by the action of hydrochloric acid on casein. He found that the diamido compounds formed less than 20 per ct. of the total

[16] *Zeit. f. Physiol. Chem.*, **33**: 247 (1901).

amido compounds, so that the ratio of monoamido to diamido compounds was as 1 to 0.25 or less; in other words, the monoamido compounds were greatly in excess of the diamido compounds, or just the reverse of what we find to be the case in the results embodied in the table above, based on the assumption that the nitrogen in the tannin-salt filtrate represents the total amido compounds and nothing more. The most obvious and rational explanation of this discrepancy, observed in the ratio of monoamido to diamido compounds, is that it is wrong to assume that the tannin-salt filtrate contains only amido compounds and not any peptones. Withdrawing that assumption, then, and allowing that the nitrogen in the tannin-salt filtrate represents some peptones as well as the amido compounds, how can we tell in this particular case the true amount of amido compounds in the cheese. Unquestionably, the results with phosphotungstic acid more nearly represent the truth in regard to the amido compounds, because, under the conditions of the experiment, we should expect very small amounts of amido compounds, if any; and, in this particular case, the amounts are so small as practically to indicate the absence of amido bodies altogether. From this it may be seen that it is possible for the tannin-salt reagent to give results that are decidedly misleading.

(3) *By bromine with hydrochloric acid.*— To the filtrate from the zinc sulphate precipitate in 7, we add 2 or 3 drops of strong hydrochloric acid and then bromine until the liquid becomes saturated and there remains after vigorous agitation an undissolved globule of bromine amounting to 0.5 cc. to 1 cc. This is allowed to stand over night. The precipitate is then filtered and washed with bromine-saturated water. The nitrogen in the precipitate is then determined by the Kjeldahl method and is called nitrogen in the form of peptones, the filtrate containing the amido-acid compounds and ammonia.

The use of chlorine by Rideal and Stewart[17] in precipitating proteids suggested to Allen and Searle[18] the use of bromine. They reported that bromine quantitatively precipitates the prod-

[17] *Analyst* **22:** 228 (1897).
[18] *Analyst* **22:** 259 (1897).

ucts formed by the peptic digestion of egg-albumin and they developed the method practically as given above. As applied to the separation of peptones from amido-acid compounds in cheese and milk, the method gives varying results, depending upon the age of the cheese or milk used.

In the case of our water-extracts made from cheese, nine months to a year old, crystalline bodies in noticeable quantities are precipitated by bromine along the peptones, due probably to the presence of tyrosine, giving the solution a turbid appearance and rendering filtration difficult. Schjerning[19] has shown that tyrosine behaves in this manner with bromine water. This precipitate is partly retained on the filter paper and is estimated as peptone.

Schjerning has shown also that bromine does not completely precipitate milk-proteids and their derived caseoses and peptones. Of the whole proteid, he obtained only 76.7 per cent. by bromine. In the case of milk, we have obtained results varying with the age of the milk. In perfectly fresh milk, when the amount of amido compounds must have been least, we obtained 91.3 per cent. of the entire milk proteids by bromine precipitation. In another case of fresh milk, we compared the precipitation of proteids by bromine and hydrochloric acid with that by tannin and sodium chloride and by solution of phosphotungstic acid and sulphuric acid, with the following results:

Precipitated by—	Percentage of total nitrogen
Phosphotungstic and sulphuric acids	93.8
Tannin and sodium chloride	93.3
Bromine and hydrochloric acid	91.5

There is also a possible source of error in connection with the use of bromine in precipitating peptones, when the filtrate from the bromine precipitate is used directly for the determination of amido-acid compounds. We have found in the case of water-extracts from cheese over one year old that there is an actual loss of nitrogen when bromine is allowed to stand in contact

[19] *Zeit. f. Analyt. Chem.* 39: 545 (1900).

with the water-extract. In the case of one cheese two years old, the cheese extract, consisting of caseoses, peptones, and amido-acid compounds, contained nitrogen equivalent to 2.74 per ct. of the cheese before adding bromine, while, after standing one hour in contact with bromine in hydrochloric acid solution, there remained only 1.52 per ct. of nitrogen; in other words, there had disappeared 44.6 per ct. of the nitrogen present before the addition of bromine. In cheese one year old we have found the loss varying from nothing in one case to over 5 per ct. in others. To show whether or not this loss came from the action of bromine on the caseoses or peptones, we removed the caseoses with zinc sulphate and, in another sample of cheese extract, we removed the caseoses and peptones with phosphotungstic acid and the loss still occurred. By passing a current of air through the above extract in contact with bromine and then through potassium hydroxide and through sulphuric acid, these reagents were found free from nitrogen compounds, indicating that the lost nitrogen disappeared in the form of free nitrogen and not in the form of ammonia or nitrogen oxides. We cannot regard the method of determining the amount of peptones in cheese extracts by means of bromine as a reliable method; because, first, bromine precipitates small amounts of tyrosine and perhaps certain other similar compounds; second, it is not a complete precipitant of caseoses and peptones; and, third, its filtrate cannot be used for the determination of amido-acid compounds, especially in old cheeses, owing to the decomposing effect of bromine upon such compounds, setting nitrogen free. In addition, bromine is a most disagreeable reagent to handle.

(4) *Comparative value of different reagents used in separating peptones and amido-acid compounds.*—We have now considered in some detail each of the three reagents most commonly used in separating peptones from amido-acid compounds, viz: (1) Tannin-salt solution, (2) phosphotungstic acid with sulphuric acid, and (3) bromine with hydrochloric acid. Tannin and salt solution fails as a perfect reagent for the separation, because it does not completely precipitate peptones, which results in making the quantitative results for amido-acid compounds too high and may indicate the presence of considerable quantities of amido com-

pounds even when they are practically absent. Phosphotungstic acid, on the other hand, completely precipitates peptones, but also precipitates some of the amido-acid compounds that are present in cheese and milk, and the consequence is that the amount of amido-acid compounds found is too low. Bromine is open to both objections,— it fails to precipitate peptones completely and at the same time does precipitate some of the amido-acid compounds. While these two sources of error might tend to offset each other under certain conditions, we cannot depend upon such a method for reliable quantitative results.

In our judgment, it is desirable, for best results, to use phosphotungstic acid to separate peptones and amido-acid compounds, when the amount of amido-acid compounds is relatively small as compared with peptones or when they consist mostly of monoamido compounds. This condition occurs in the early stages of cheese ripening and persists longer in cheese cured at low temperatures; it occurs also in milk and cheese acted upon by pepsin enzymes, especially in the presence of chloroform.

Tannin-salt solution can be relied upon to give better results than phosphotungstic acid, when amido-acid compounds are present in proportions that are relatively large compared with peptones or when they consist largely of diamido compounds. The former condition prevails in normal cheese cured under usual conditions, especially after the first few weeks of curing.

10. DETERMINATION OF NITROGEN IN THE FORM OF AMMONIA.

We distil with magnesium oxide 100 cc. of the filtrate from the tannin-salt precipitation, passing the distillate into a standardized acid and titrating in the usual way. In our early work the cheese-mass itself, suspended in water, was used for distillation, giving slightly higher results than the method just described. The small increase is generally accounted for as coming from the proteids themselves present in the solution. Theoretically, it is true that when such bases are present as putrescine and cadaverine, they might distil with the ammonia. In one case where a large quantity of cheese was subjected directly to distillation with magnesium oxide and the distillate examined for these bases, none was found, the distillate consisting entirely of the

ammonia salt. The high boiling points of cadaverine and putrescine and the consequent difficulty of distilling them with steam probably accounts for their absence in the distillate.

In our early work on the determination of ammonia in milk and cheese, we subjected to distillation with magnesium oxide and with barium carbonate many different amido compounds, in order to ascertain if any of these bodies, when pure, could split off basic nitrogen. While some of the products used in our work are not at all likely to be found in cheese or milk, we include them with the others in the table given below. The method was carried out as follows: We dissolved 1 gram of each amido body, or, if insoluble, suspended it, in 50 cc. of water, and, for distillation, used 10 cc. of this mixture diluted to 150 cc., adding magnesium oxide or barium carbonate and using ordinary atmospheric pressure.

TABLE III.—EFFECT OF DISTILLING AMIDO BODIES WITH MAGNESIUM OXIDE AND WITH BARIUM CARBONATE.

	Amount distilled over with magnesium oxide.	Amount distilled over with barium carbonate.
Acetamide	0	0
Allantoin	0	0
Arginine[20]	0	0
Aspartic acid	0	0
Creatin	0	0
Creatinin	0	0
Diphenylamine	0	0
Glutamic acid	0	0
Glycocoll	0	0
Histidine	0	0
Leucine	0	0
Lysine	0	0
Phenylenediamine	0	0
Trimethylamine	completely distilled.	completely distilled.
Tyrosine	0	0
Uric acid	0	0
Xanthin	0	0

[20] *Zeit. f. Physiol. Chem.*, **34**: 145 (1901).

We have also used the excellent Nencki apparatus, distilling under reduced pressure the filtrarte from the tannin-salt precipitation. In comparative trials we have obtained no lower results than when we distil under ordinary atmospheric pressure.

11. DETERMINATION OF NITROGEN IN THE FORM OF UNSATURATED PARACASEIN LACTATE.

The residue insoluble in water is treated with several portions of a 5 per ct. solution of sodium chloride, the process being carried out as in preparing the water extract in 3 above. The nitrogen in an aliquot part of the 500 cc. of this salt-extract is determined by the Kjeldahl method.

II. METHODS FOR THE SEPARATION AND ESTIMATION OF THE NITROGEN COMPOUNDS OF MILK AND THEIR PROTEOLYTIC PRODUCTS.

We will briefly describe the methods used for the separation and estimation of the nitrogen compounds of milk and their proteolytic products in the following order:

1. Determination of total nitrogen in milk.
2. Determination of nitrogen in the form of casein.
3. Determination of nitrogen in the form of albumin and syntonin.
4. Determination of nitrogen in the form of caseoses.
5. Determination of nitrogen in the form of amido-acid compounds.
6. Determination of nitrogen in the form of peptones.
7. Determination of nitrogen in the form of ammonia.

1. DETERMINATION OF TOTAL NITROGEN IN MILK.

Weigh about 5 grams of milk and determine the nitrogen by the Kjeldahl method.

2. DETERMINATION OF CASEIN.

To about 10 grams of milk add 90 cc. of water at 104° F. to 108° F. (40° C. to 42° C.) and then 1.5 cc. of 10 per ct. acetic acid. Agitate and warm at the temperature given above until

a flocculent precipitate separates, leaving a clear supernatant liquid. Filter, wash and treat by the Kjeldahl method for estimating nitrogen.

In fresh milk, 2 or 3 cc. of a saturated solution of alum may be used in place of acetic acid, usually with little higher results. But when the milk-casein has been proteolyzed to any extent, the use of alum is not permissible, since it precipitates caseoses in addition to casein.

The use of acetic or any other acid in precipitating casein in milk, whose casein has been digested in any degree, precipitates, in addition to casein, any paranuclein that is present. We have not yet succeeded in devising satisfactory methods for the separation of these compounds.

3. DETERMINATION OF NITROGEN IN THE FORM OF ALBUMIN AND SYNTONIN.

The filtrate from 2 is neutralized by caustic alkali, using phenolphthalein as indicator and is then heated at the temperature of boiling water until the precipitate completely separates and settles. The precipitate is then filtered, washed and treated by the Kjeldahl method.

4. DETERMINATION OF NITROGEN IN THE FORM OF CASEOSES.

The filtrate from 3 we heat to 158° F. (70° C.), add 1 cc. of 50 per ct. sulphuric acid and then c. p. zinc sulphate to saturation. Let stand at the temperature indicated until the caseoses completely separate and settle. Then cool the mixture, filter, wash with a saturated solution of zinc sulphate made slightly acid with sulphuric acid, and treat the precipitate by the Kjeldahl method.

5. DETERMINATION OF NITROGEN IN THE FORM OF AMIDO-ACID COMPOUNDS.

Treat about 50 grams of milk with a tannin-salt solution or with phosphotungstic acid as described in case of cheese, under 8, p. 201.

6. DETERMINATION OF NITROGEN IN THE FORM OF PEPTONES.

From the total nitrogen subtract that found in all forms other than that of peptones as indicated in case of cheese, under 9, pp. 202-211.

7. DETERMINATION OF NITROGEN IN THE FORM OF AMMONIA.

See under 10, methods for cheese, p. 211.

III. DETERMINATION OF CHLOROFORM.

When chloroform is used as an antiseptic in milk and cheese, it is very essential to know approximately the amount present in order that we may have a proper control of conditions. We have used the following method successfully: We place 5 grams of milk or cheese in a pressure bottle with about 100 cc. of alcohol and 5 grams of caustic potash. The bottle is then heated in an autoclave for half an hour at 230° F. (110° C.). The resulting chloride is determined by titration as for chlorine in sodium chloride.

SOME OF THE COMPOUNDS PRESENT IN AMERICAN CHEDDAR CHEESE.*

L. L. Van Slyke and E. B. Hart.

SUMMARY.

1. Very little systematic work has been done in ascertaining the different compounds formed in cheese during the process of ripening. Such work must be done before we can understand the details of the process of cheese-ripening. This bulletin contains the first results of an extended systematic investigation in this field of work.

2. Paranuclein or pseudonuclein is a compound soluble in water but completely precipitated by 0.2 per ct. hydrochloric acid. It has been found in all cheeses examined by us.

3. In a cheese 4½ months old there were found the three basic products, lysatine, histidine and lysine.

4. In a cheese 15 months old there were found tetramethylene-diamine (putrescine) and lysine.

5. Later we may find that these or similar products are responsible, to some extent, for the flavors of cheese.

INTRODUCTION.

As cheese ages or ripens, the nitrogen compounds present in the fresh cheese undergo change in composition more or less profound in character. To the general process that embraces these and other changes is applied the term "cheese-ripening." In a thorough study of the cheese-ripening process, it is of fundamental importance that we ascertain what specific compounds are formed. We must possess such knowledge before we can understand fully in what way different conditions affect the

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ripening process. The more complete our knowledge is in respect to the various individual compounds formed in cheese-ripening, the better can we understand the causes that produce, and the conditions that control, the process. Whether or not cheese-ripening is in part, or in whole, a biological process, our knowledge of the details of the process must depend very largely upon our knowledge of the specific chemical compounds resultining from such action.

More or less work of a desultory character has been done in this field. Special difficulties are met in the isolation and study of the individual proteolytic compounds found in cheese, owing to a lack of knowledge regarding the chemical constitution of many of them and also to the minute quantities commonly available. Then, too, the same compounds are present or absent according to the conditions of ripening, even in cheese of the same variety. In different kinds of cheese, there is still greater variation. Thus far, we have confined our attention to the study of American cheddar cheese, the type most commonly made in this country.

The presence of ammonia was early noticed in cheese. In 1818 Proust[1] discovered in old cheese leucine, which he called "caseous oxide." In 1880 Siber[2] found tyrosine in a sample of rocquefort cheese. In 1882 Weidmann[3] undertook an investigation of the chemical compounds of emmenthaler cheese more thorough than had been previously attempted. He was the first to call attention to a product soluble in hot alcohol, called by him "caseo-glutin," which we have recently shown to be unsaturated paracasein lactate.[4] Röse and Schulze[5] in 1885 were the first to mention the presence of nuclein in cheese, though their work was largely qualitative. In 1887 Benecke and Schulze[6] added to the list of nitrogen compounds previously found in emmenthaler cheese phenylamidopropionic acid. Recently Winterstein and Thöny[7] have reported in emmenthaler

[1] *Annal. de Chim. et de Phys.*, [2] **10**: 40 (1818).
[2] *Jour. f. Prak. Chem., N. F.*, **21**: 213 (1880).
[3] *Landw. Jahrb.*, **11**: 587 (1882).
[4] N. Y. Agr. Exp. Sta. Bul. No. 214 (1902).
[5] *Landw. Versuchst.*, **31**: 115 (1885).
[6] *Landw. Jahrb.*, **16**: 317 (1887).
[7] *Zeit. f. Physiol. Chem.*, **36**: 28 (1902).

cheese the following compounds: Histidine, lysine, guanidine probably, tetramethylenediamine (putrescine) and pentamethylenediamine (cadaverine). In very few cases do we know anything of the history of the cheese used in the investigations. In our work we are familiar in most cases with the history of the cheese, including the conditions of manufacture and of ripening.

EXPERIMENTAL PART.

PARANUCLEIN (PSEUDONUCLEIN).

In the work first done about ten years ago in this laboratory in the study of cheese-ripening, a substance was precipitated by dilute acids from the water-extract of cheese, showing the general chemical behavior of milk-casein toward different reagents. This was called "soluble casein" in the absence of knowledge of its specific chemical composition. During the past three years we have given more or less attention to the study of this substance and, though our work is still incomplete, we present here the results obtained up to the present time.

The fact that the substance in question was precipitated by dilute acids, completely by 0.2 per ct. hydrochloric acid, suggested its resemblance to Chittenden's so-called casein-dyspeptone,[8] the insoluble substance obtained in larger or smaller quantities when milk-casein is digested with pepsin and hydrochloric acid.

The substance is obtained from cheese by extraction with water and precipitation by hydrochloric acid. We cover about 3 kilograms of finely ground cheese with water, digest it at 55° C. for half an hour and then decant the extract. The residue is again covered with water, digested and decanted as before, this operation being repeated several times until the extract amounts to 4 or 5 liters. After filtration through absorbent cotton, the solution is cooled to 10° C. or lower and allowed to stand until the fat separates as a solid layer on the surface, which can be readily removed. The solution is then heated to 50° to 55° C. and treated with enough hydrochloric acid to equal 0.2 per ct. of the solution. The paranuclein separates as a floc-

[8]Studies in Physiol. Chem. Yale Univ., **3:** 66 (1887–8).

culent white precipitate, settling to the bottom of the vessel, leaving a supernatant liquid of a bright yellow color. The separation of the precipitate may be hastened by vigorous stirring. The precipitate is filtered, washed with water and then dissolved in 1 or 2 liters of 1 per ct. solution of sodium carbonate. The resulting solution appears to be complete, though it is milky in appearance. It is filtered, reprecipitated by dilute hydrochloric acid and the precipitate filtered and washed. This process of redissolving and reprecipitating is repeated three or four times in all. From this point, two different methods may be employed for further purification of the substance. By one method, the third or fourth precipitate by hydrochloric acid is thoroughly washed with water containing dilute hydrochloric acid, then with alcohol, and finally with ether, after which it is extracted by boiling ether for several days, until all traces of fat are removed. It is then dried to constant weight at 105° to 110° C. for analysis. By the other method, the third or fourth solution in dilute sodium corbonate is made exactly neutral by hydrochloric acid, treated with 3 per ct. of chloroform to prevent any bacterial action and dialyzed in running water until all chloride is removed. The resulting solution is concentrated on the water-bath to a thick syrup and while still warm is poured into a mixture of 95 per ct. and absolute alcohol. This is allowed to stand 2 or 3 days. A white gelatinous coagulum results, which is filtered, washed thoroughly with alcohol, placed under absolute alcohol several days, again filtered, treated with cold ether, then dried, powdered and extracted with boiling ether until all fat is removed. It is then finally dried to constant weight at 105° to 110° C. This method of dialyzing, concentrating and then precipitating by alcohol in neutral or alkaline solution appears usually to carry down with the precipitate large quantities of ash. Jackson[9] has pointed out this fact and has shown that this may be avoided by using the first method given above or by precipitating with alcohol in the presence of dilute acid.

We present in the table below the results of analyses of samples of the substance prepared from different cheeses. The

[9] *Am. Jour. Physiol.*, **4**: 170 (1900).

figures given are on the basis of ash-free substance. The first five samples were prepared by dialysis and precipitation by alcohol in neutral or slightly alkaline solution, except sample 3, in which case the solution was probably slightly acid. The other samples were prepared by the first method described above. In samples 6, 7 and 8 the amount of material obtained was not sufficient for making all the determinations.

TABLE I.—ANALYSIS OF PREPARATIONS OF PARANUCLEIN OBTAINED FROM DIFFERENT CHEESES.

	C.	H.	N.	S.	P.	O.	Ash.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1. Cheese bought in open market, 3 months old.	48.51	6.81	14.14	3.19	2.50	24.95	31.53
2. Cheese bought in open market, 3 months old.	48.46	5.67	13.25	2.00	2.23	28.39	23.65
3. Cheese 4½ months old..	52.01	6.98	14.17	1.65	1.41	23.78	1.44
4. Cheese 7 months old, interior...............	50.60	7.00	13.65	1.00	1.33	26.32	16.64
5. Same, 7 months old, exterior...............	50.56	7.70	14.36	0.86	1.52	25.00	20.22
6. Cheese 1 month old....	46.72	6.86	15.91	......	......	......	......
7. Same, 2 months old....	47.59	6.90	12.36	......	......	......	......
8. Same, 3 months old....	48.82	7.43	12.98	......	......	......	......
9. Same, 4 months old....	50.56	6.73	12.96	0.83	1.13	27.79	3.10
10. Same, 5 months old....	53.12	6.51	13.68	0.89	0.98	24.82	4.42

An examination of the results indicates that we probably did not succeed in freeing the substance from impurities. The few analyses of nuclein on record show considerable divergence. In comparison with Chittenden's casein-dyspeptone, the content of nitrogen, hydrogen and carbon is lower in our substance, while the sulphur is considerably higher. Chittenden regarded the phosphorus as consisting entirely of calcium phosphate, but Jackson has shown that paranuclein yields over 2 per ct. of organic phosphorus, if care is taken to prevent calcium phosphate from being precipitated with the substance and to avoid the formation of inorganic phosphates during ignition. We shall give our attention further to methods of separating paranuclein from cheese in the hope of being able to prepare it free from impurities and studying its decomposition products.

Paranuclein results from the breaking down of casein or paracasein and is always found in the water-extracts of ripening cheese. The amounts commonly found in cheese under different conditions we shall discuss in a future paper.

AMIDO COMPOUNDS.

In the work, an account of which follows, we planned to isolate such diamido compounds as might be present in the cheese examined. Two different cheeses of the normal American cheddar type were used to furnish material for our work. One was $4\frac{1}{2}$ months old and had been ripened at a temperature of 18° C., possessing a mild and pleasant flavor; the other was 15 months old and had been ripened at a temperature of about 20° C., possessing a somewhat pungent but not disagreeable flavor. In preparing the samples for examination, the cheese was cut into small pieces, the rind being excluded. We used 8 to 10 kilograms of each cheese. After drying in air at room temperature, the cheese was placed in large bottles, covered with 90 per ct. alcohol and digested for several days at room temperature, with frequent agitation. The resulting alcoholic solution, which was of a rich yellow color, was filtered through filter paper from the insoluble portion, the latter being allowed to drain thoroughly. The insoluble residue was then dried at 60° C., in order to remove all alcohol, and furnished a white, crumbly mass. Most of the fat had been removed by the alcohol and probably some small proportion of the amido-acid compounds. This white mass was next extracted with several portions of water at 55° C., and the extracts filtered through absorbent cotton, until about 25 liters of extract were obtained. This water-extract was treated with tannin in excess, a copious precipitate of caseoses and peptones resulting, which was removed by filtration. The excess of tannin in the filtrate was removed by careful addition of lead acetate, until a drop of the reagent gave no further turbidity, after which the precipitate of lead tannate was filtered and washed with water. The excess of lead in this filtrate was then carefully removed by the addition of sulphuric acid, until a drop gave no additional precipitate, the final traces of lead being removed by hydrogen

sulphide. The filtrate from the precipitates of lead sulphate and lead sulphide were united, concentrated to small volume on a water-bath, then made alkaline with barium carbonate and finally boiled about 15 minutes in order to remove all ammonia. The solution was then made slightly acid with sulphuric acid, the precipitated barium sulphate removed by filtration and the filtrate made to contain 5 per ct. acid by adding sulphuric acid, after which it was precipitated by phosphotungstic acid. A heavy crystalline precipitate resulted, which was filtered and washed with 200 cc. of 5 per ct. sulphuric acid. The phosphotungstic acid precipitate was then suspended in water and treated with barium hydroxide to remove the phosphotungstic acid in the well-known way. The excess of barium was removed by carbon dioxide, the precipitate filtered and washed. This gave a solution, which should contain the hexon bases, viz.: arginine, lysine, histidine and lysatine. For the separation of the first three compounds, the Kossel-Kutscher method was employed, and, for lysatine, Siegfried's method. To this solution, diluted to 2 liters and made slightly acid by sulphuric acid, was added a solution of silver nitrate, until a drop of the solution placed on a white porcelain surface gave with barium hydroxide the yellow precipitate of silver oxide, thus showing excess of silver nitrate. Then, barium hydroxide was added to saturation, which formed a somewhat slimy precipitate, filtering slowly. The precipitate was filtered and washed with saturated solution of barium hydroxide. The filtrate (Solution A) was worked for lysine, and the precipitate, for lysatine, histidine and arginine. The precipitate was suspended in warm water and the barium carefully removed by means of sulphuric acid and the silver by hydrogen sulphide. The precipitate was filtered, washed with water and the filtrate made to 1 liter (Solution B).

In cheese 15 months old.— In 10 cc. of Solution B, the nitrogen was determined and found to be 0.00041 gram or a total of 0.041 gram in the entire extract. This small amount of nitrogen indicates that arginine, histidine and lyastine were present in exceedingly minute quantities, if at all. It is possible that the small amount of nitrogen present was due to slight traces of peptones which tannin failed to remove.

LYASTINE.

In cheese 4 1-2 months old.—To Solution B, obtained as described above, we added just enough barium nitrate to remove all sulphuric acid, filtered and concentrated the filtrate to small bulk. Silver nitrate was carefully added until the presence of an excess was shown by the usual test and then a few drops of dilute nitric acid were added. Alcohol was next added and a precipitate began to form, when the addition of alcohol was continued until its volume equalled the volume of the solution. Then a small amount of ether was added, when a crystalline precipitate was formed. This was allowed to stand 24 hours and then filtered, washed with ether and dried over sulphuric acid, yielding a product weighing 2.1 grams. The filtrate was used for separating histidine. This product behaved like Siegfried's lysatine and analysis shows its similarity to that body.

0.202 gram substance gave 0.0565 gram Ag.

0.214 gram substance gave 74.5 cc. N at 22° C. and 746 mm.

Percentages:	Calculated for lyastine silver nitrate, (C_6 H_{13} N_3O_2 HNO_3 Ag NO_3)	Found
Ag	27.51	27.97
N	17.90	17.89

A portion of the lyastine silver nitrate, obtaining as described above, was treated with hydrochloric acid and evaporated nearly to dryness, this operation being repeated several times to remove the greater part of the nitric acid. Platinum chloride was then added and the solution evaporated nearly to dryness, when, on addition of alcohol, the platinum salt of lyastine separated. This was filtered, washed with alcohol and dried over sulphuric acid *in vacuo*. Analysis gave the following results:

0.2414 gram substance gave 0.0835 gram Pt.

Percentages:	Calculated for lysatine platinum chloride, (C_6H_{13} N_3O_2 H_2 Pt Cl_6)	Found
Pt	34.28	34.58

HISTIDINE.

In cheese 4 1-2 months old.—The filtrate obtained from the precipitate of lysatine, as described above, was carefully evaporated on the water-bath to remove ether and alcohol and then

treated with barium hydroxide until one drop of the clear supernatant liquid, added to an ammoniacal solution of silver nitrate, gave no precipitate, thus showing the complete precipitation of histidine. This precipitate was filtered, washed with water and then suspended in water and treated with hydrogen sulphide to remove silver. After the silver sulphide was filtered, the filtrate was evaporated to dryness, this residue extracted with dilute silver nitrate, containing a few drops of nitric acid and the extract precipitated with ammonia, filtered, and washed with water. This precipitate was next suspended in water, decomposed by hydrochloric acid, the silver chloride filtered and washed and the filtrate concentrated and allowed to stand several days, when crystals began to separate. After standing a few days longer, the liquid was filled with crystals. The crystalline mass was washed with ether and dried over sulphuric acid *in vacuo,* yielding 4.1 grams histidine.

0.374 gram substance gave 0.1156 gram Cl.

0.2918 gram substance gave 0.532 gram N.

Percentages:	Calculated for histidine hydrochloride, ($C_6H_9N_3O_2 2HCl$)	Found
Cl	31.11	30.93
N	18.42	18.23

ARGININE.

In cheese 4 1-2 months old.—The filtrate from the histidine precipitate was saturated with barium hydroxide, the precipitate filtered, washed with solution of barium hydroxide, suspended in water acidulated with sulphuric acid, and the silver removed by hydrogen sulphide. The entire filtrate contained only 0.085 gram nitrogen, equivalent to 0.255 gram arginine. The amount was too small to obtain as a crystalline product, and we are led to conclude that arginine does not exist in appreciable quantities in cheese of this age. Winterstein and Thöny[10] have also reported a similar result in case of emmenthaler cheese, the age of which, however, they do not state.

[10]*Zeit. f. Physiol. Chem.*, 36: 28 (1902).

LYSINE.

Solution A, obtained as described on p. 222, was freed from barium by sulphuric acid and from silver by hydrogen sulphide, and the filtrate from these precipitates concentrated to small volume. The solution was made to contain 5 per ct. of sulphuric acid and precipitated with phosphotungstic acid. The precipitate was filtered, washed with dilute sulphuric acid, suspended in water, decomposed by barium hydroxide, filtered, and the excess of barium removed by carbon dioxide, the solution then being concentrated to small volume.

In cheese 15 months old.— To the solution thus concentrated, alcohol of 95 per ct. strength was added in quantity equal to twice the bulk of the solution. Picric acid was then added. On standing 24 hours, no precipitate appeared. The alcohol was then evaporated, the solution concentrated and saturated picric acid solution added, when crystals began to appear and increased considerably on standing over night. The crystals were filtered, washed with cold water, recrystalized four times from water, finally washed with ether and dried over sulphuric acid, yielding 9.2 grams (Fraction No. 1).

The filtrate from the first fraction of crystals was further concentrated by evaporation and more picric acid was added, producing a small additional yield of crystals. These were filtered, washed with ether and alcohol and dried over sulphuric acid, yielding 0.8 gram (Fraction No. 2).

The last filtrate was further concentrated by evaporation, when a slimy precipitate separated. The whole mixture was then shaken with ether in sulphuric acid solution in order to remove all picric acid, after which it was repeatedly boiled with animal charcoal and filtered to remove all coloring matter. The solution was then reprecipitated by phosphotungstic acid, the precipitate decomposed by barium hydroxide, filtered, and excess of barium removed by carbon dioxide, the resulting solution being concentrated to small bulk by evaporation. Alcohol was added equal in amount to twice the volume of the solution and picric acid carefully added. A crystalline precipitate began to form and increased on standing. After 24 hours the crystals were

filtered, washed with alcohol, recrystallized three times from water, finally washed with ether and dried over sulphuric acid yielding 14.1 grams (Fraction No. 3).

The last filtrate was further concentrated by evaporation and yielded an additional crop of crystals, weighing 0.2 gram (Fraction No. 4).

The crystals contained in Fractions 3 and 4 behaved like lysine and showed, on analysis, a composition corresponding to this compound.

Percentages:	Calculated for lysine picrate. ($C_6H_{14}N_2O_2$ C_6 H_2 (NO_2) 3O H)	Found
N	18.66	19.17
C	38.40	38.18
H	4.53	4.21

On converting this salt to a chloride and estimating the chlorine, the following results were obtained:

0.277 gram substance gave 0.3616 AgCl.

Percentages:	Calculated for lysine hydrochloride. ($C_6H_{14}N_2O_2$ 2HCl)	Found
Cl	32.39	32.24

In cheese 4 1-2 months old.—We obtained 5.4 grams of lysine. A portion recrystallized several times from water gave 18.81 N, the calculated amount being 18.66 N.

TETRAMETHYLENEDIAMINE (PUTRESCINE).

In cheese 15 months old.— Fraction No. 1 of crystals, obtained as described above, resembled tetramethylenediamine in its solubilities and an analysis showed its identity in composition with this compound.

Percentages:

	Calculated for tetramethylenediamine picrate. ($C_4H_{12}N_2$ $2C_6H_2(NO_2)$ 3O H)	Found
N	20.51	20.34
H	3.29	3.48
C	35.16	35.40

On converting this compound to a chloride, the following amount of chlorine was obtained:

0.206 gram substance gave 0.365 gram AgCl.

Percentages:		
	Calculated for tetramethylenediamine hydrochloride, $(C_4H_{12}N_2\ 2HCl)$	Found
Cl	44.06	43.76

In cheese 4 1-2 months old.—We expected to find putrescine in this cheese as in the others, since arginine, of which it forms a reduction product, was not found; but we were unable to obtain this compound.

ISOLATION OF AMMONIA FROM RIPENING CHEESE.

We ground with sand 500 grams of a normal cheddar cheese, ripened at 13° C., 10 months old. We extracted this with water at 55° C., precipitated the water-extract with tannin, filtered and distilled the filtrate with steam into a dilute solution of hydrochloric acid. The distillate was evaporated after addition of platinum chloride and the ammonium salt isolated, yielding 8.1 grams of ammonium chlorplatinate. After drying over sulphuric acid, the following analytical results were obtained:

Percentages:	Calculated for ammonium chlorplatinate. $((NH_4)_2PtCl_6)$	Found
Pt	44.21	44.22

Since we had found in the cheese 15 months old the volatile base putrescine, it was thought possible that small amounts of this base might distil over when the estimation of ammonia was made by distillation with magnesium oxide, thus vitiating the results in the ordinary method of estimation by increasing the amount of nitrogen obtained as ammonia. In the case of the cheese used and under the conditions of experiment, no such contamination was observed.

DISCUSSION OF RESULTS.

Summarizing the results secured by the work embodied in the preceding portion of this paper, we find (1st) *paranuclein* as a common constituent of all cheeses examined by us; (2d) in the younger cheese, which was 4 1-2 months old, the three basic products, *lysatine, histidine* and *lysine;* and (3d) in the older cheese, which was 15 months old, *tetramethylentdiamine* (putrescine) and *lysine.*

In neither case were we able to separate arginine, but in the older cheese we found putrescine, one of the reduction[11] products of arginine. We did not look for guanidine, but this compound might be expected to be present as the other cleavage product of arginine, and Winterstein and Thöny have reported its probable presence in emmenthaler cheese. While there is some reason to believe that lysatine is composed of arginine and lysine, the point is not clearly settled and in our discussion we have not assumed this to be the case.

It is known that lysine[11] yields also pentamethylenediamine (cadaverine) on reduction, and Winterstein and Thöny have reported the presence of the latter compound in an emmenthaler cheese. They do not give any facts in relation to the history of the cheese used in their work and we are unable, therefore, to make any comparison with our cheese 15 months old, in which we found one of the reduction products of arginine, viz.: putrescine. Whether cadaverine might have been formed ultimately, we cannot say.

There appears to be good evidence that there is regularly in the cheese-ripening process, in the case of hard cheeses like emmenthaler and American cheddar, a conversion of primary into secondary amido compounds; and these chemical changes may explain, perhaps, the gradual development of flavor in normal cheese; in other words, we may find that the changing flavor of cheese, as it ages, is due, to some extent, to increasing quantities of secondary amido compounds.

In flavor, the older cheese used by us was rather pungent but not unpleasantly so. It had a high ammonia content, which is a marked characteristic of cheese ripened at temperatures above 16° to 18° C. and which also is a usual accompaniment of a pungent flavor. In cheese ripened in cold storage, where the temperature is usually below 5° C., small amounts of ammonia are found and the flavor is very mild. We must bear in mind, however, that the presence of mere traces of such compounds as putrescine, cadaverine and ammonia will not suffice to account for marked abnormal sharpness or other unpleasant quality of flavor in cheese, but that they gradually accumulate and finally

[11] Ellinger. *Zeit. f. Physiol. Chem.*, **29**: 334 (1900).

are present in quantities such that we might expect them to predominate and impart to the cheese mass the flavors peculiar to them.

In cheese, technically known as "gassy," characterized by formation of considerable quantities of different gases, hydrogen forms a part of the gas, so far as examinations that have been made show, and this gas can be regarded as an agent easily capable of favoring the early formation of the reduction products that have been found, viz.: putrescine, cadaverine and ammonia.

The subject of cheese flavors is one of complex difficulties, but it is safe to say that these flavors are due to the presence of specific compounds, and any work that shows in cheese the formation and presence of compounds capable of imparting flavors will contribute to the solution of a problem whose details are now little understood.

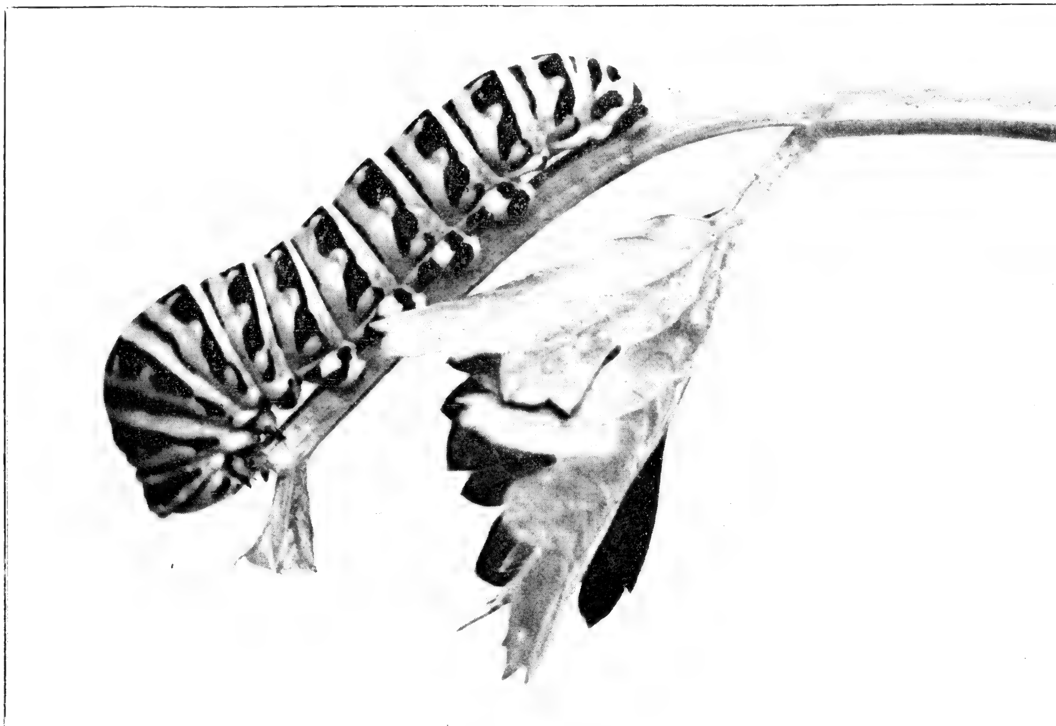

Plate XXI.—Larva of *Papilio asterias* on Celery Stalk.

REPORT

OF THE

Department of Entomology.

V. H. LOWE, *Entomologist.*

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[1]Second Judicial Department.

[2]Resigned August 1, 1902.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

MISCELLANEOUS NOTES ON INJURIOUS INSECTS. II.*

V. H. Lowe.

SUMMARY.

A brood of the periodical cicada is due to appear this spring. It is located in Niagara, Monroe, Kings, and Richmond counties in this State, and in 18 of the central, southern and eastern states and the District of Columbia. It is probably the largest of the 17-year broods. The adult females injure trees, shrubs and vines by puncturing the twigs and small branches in order to deposit eggs in the wood. The injury is not usually serious except when the insects occur in very large numbers. There seems to be no practical method of destroying the adults when occurring in sufficient numbers to do serious injury.

The palmer worm was very abundant in some of the apple orchards in western New York during the spring of 1900. It has practically disappeared and is now found only occasionally. The insect has been noted as a species that appears suddenly in large numbers and disappears as quickly as it came, not to appear again for several years.

White grubs were found very destructive to aster plants grown in the field. The same field was in nursery trees the season before and while the grubs had not injured the trees sufficiently to be noticed, they were there in sufficient numbers to cause serious injury to the asters. The only practical remedy found was to pull up the infested plants and destroy the grubs.

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*A reprint of Bulletin No. 212.

The celery caterpillar, *Papilio asterias,* is found in varying numbers every year. During the past two years it has been unusually abundant in western New York, causing injury, especially to celery in the seed bed. It is easily checked by spraying with paris green, where practical, or jarring the caterpillars to the ground and destroying them.

INTRODUCTION.

This bulletin is the second of a series dealing with miscellaneous notes on injurious insects, of which Bulletin No. 180 is the first. These notes aim to deal principally either with subjects that are considered of too little importance at the time to be the objects of extended investigation, but are of too much interest to be laid aside; or with topics upon which immediate information is desired. In some cases they may be preliminary to a more exhaustive discussion to appear in a later publication.

While, in the main, the notes are intended to be the result of our own observations, the demand for immediate information concerning species that have been but little studied here at the Station sometimes makes desirable a collection of data from other publications. In such cases the literature of the subject is drawn upon freely.

I. THE PERIODICAL CICADA.

Much interest is again being manifested in the periodical cicada or, as it is more often called, the seventeen-year locust, because of the expected appearance above ground during the spring of 1902 of one of the largest broods known in the United States. Considerable anxiety, especially on the part of fruit-growers, is also apparent as to the probability of injury to young trees and vines. As a result there is much demand within the State for information concerning this species. It may be added, however, that the peculiar interest with which this insect is viewed lies not alone in the fact that many are apprehensive of injury to their crops, nor even in its interesting habits above ground; but one naturally considers it no small privilege to look upon a living, active creature that has just emerged from a comfortable sojourn of seventeen years under the sod.

The interesting habits of the cicadas, their appearance in great swarms, and the noisy way in which they proclaim their presence, early attracted attention. The species is a native of America, and probably the first known record of its appearance is found in Moreton's New England Memorial in which it is stated that a swarm appeared in Plymouth in the spring of 1633[1].

The periodical cicada was originally described by Linné, who gave it the scientific name *Cicada septendecim,* publishing the description[2] in 1758. It has been suggested[3] that the popular but incorrest name " seventeen-year locust " probably originated with the early settlers who associated the swarms of cicadas with the devastating hordes of migratory locusts.

The unusual interest attached to this species has also resulted in its being made the subject of investigation from the time of the earliest entomologists until the present day. The difficulty of following a number of individuals through their long life underground, however, prevented a thorough knowledge of the insect's subterranean life until the comparatively recent investigations of the late Dr. C. V. Riley and those of C. L. Marlatt, which resulted in throwing much light on its entire life history.[4]

LIFE HISTORY.

The life history of the periodical cicada does not differ materially from that of many other species of insects except for the long life under the ground. There are many others that are known to live nearly a year in the soil, and a few, such as the common white grub, the larva of the May beetle, are about three years in the ground before emerging; but no other insect known can equal the periodical cicada for longevity.

The egg.— The eggs are laid in the twigs and smaller branches of deciduous trees. They are placed well in the wood in double rows as described on a subsequent page. The egg is at first pearly white in color, but, as the shell is very thin and semi-transparent, turns darker, probably because of the color of the

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[1]Harris. Insects Injurious to Vegetation. Second Edition, p. 180.

[2]*Systema Naturae* (tenth edition).

[3]Hopkins, A. D. W. Va. Agr. Exp. Sta. Bul. 50, p. 5.

[4]U. S. Dept. Agr., Div. of Ent., Bul. 14, n. s.

growing embryo. According to Marlatt[5] Dr. Potter has stated that this change of color is noted at 15 days and after. In shape they are oblong, slightly curved and measure about 2 mm. ($\frac{1}{12}$ in.) in length (Plate XXII, Fig. 3). They increase in size somewhat, probably by the absorption of the juices of the surrounding plant tissue. The period of incubation varies, depending apparently upon weather conditions. The usual period is probably from six to seven weeks.[6]

The larva.—When the larva is fully matured within the egg and ready to emerge, the egg shell gives way in a line along its back permitting it to escape. The newly hatched larva is an awkward, somewhat spider-like creature measuring about 1.5 mm. ($\frac{1}{16}$ in.) in length. The body is slender and sparsely covered with minute hairs. The head, legs and antennæ are long in proportion. In color it is creamy-white, marked only by deep-red eye spots and reddish claws. The most striking peculiarity of the insect, both in the larval and pupal stages, is the prominent lobsterlike front legs with which it digs its way into the ground. When the larva has gained its freedom it begins to move about actively but soon loosens its hold and drops to the ground. Owing to the lightness of its body it is not injured by the fall. After reaching the ground the first impulse of the young larva seems to be to get beneath the surface, for it soon seeks some opening by which to enter.[7]

One of the first to investigate successfully the life and habits of the larva was Dr. Riley, who undertook to follow the life of the insect through until it emerged. His investigations were begun in Missouri in 1881, but were finally turned over to a Mr. Barlow, who continued them until 1891. During these ten years the larvæ under observation had passed four stages and were ready to enter the first pupal stage. These and subsequent observations by Marlatt showed that the larvæ pass the first molt during the first year or year and a half, the second after an additional period of two years, the third after three or four years more and the fourth three or four years later.

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[5]Idem., p. 81.
[6]Marlatt. Idem., p. 80.
[7]Marlatt. U. S. Dept. Agr., Div. Ent., Bul. 14, n. s., p. 81.

During its life underground the larva grows to over nine times its length at the time of hatching. Its body becomes quite robust and somewhat wedge-shaped. The hairs scattered over the body become more numerous and coarser, while the front legs develop into formidable digging appendages.

Marlatt and others[8] have found that while the larva undoubtedly remains in one place most of the time, it may move about to some extent. It lives within a cell of compact earth, which is usually formed so that one or two fine roots of the food plant run through the walls in easy access of the insect's beak. It may thus obtain nourishment by thrusting its beak into the tissue and sucking the sap.

The pupa.— The pupa resembles the larva in its advanced stage but the red eye-spots are wanting and the true eyes show more prominently. The rudimentary wings have also become quite prominent, while the front legs are much developed and are well fitted for digging. The habits of the pupa while it remains under ground are practically the same as those of the larva. It passes two molts.

Location in the soil.— There has been much difference of opinion as to the depth in the soil to which the larvæ and pupæ are capable of going. Observations have shown that the usual depth is from one to one and a half feet. One instance has been recorded,[9] however, where the pupæ came up in the bottom of a cellar. In another case they came up through a mass of cinders five feet thick. Other cases have been reported where they were found ten feet or more below the surface of the ground. Another instance was observed by the writer where the pupæ had evidently remained for some time at a much shallower depth. In this case they appeared in an old orchard. A large number of examinations showed that the average distance of the pupæ beneath the surface of the soil was about eight inches. A feature of considerable interest in connection with the life of the insect under ground is its ability to live in soil that has been under water for some time. At least two instances of this kind have been recorded. In one case the ground was annually

[8] Idem., pp. 91 and 93.
[9] Marlatt. U. S. Dept. Agr., Div. Ent., Bul. 14, n. s., p. 92.

EXPLANATION OF PLATES.

PLATE XXII.—1, *Pupa-case of periodical cicada;* 2, *Cases from which adults failed to escape;* 3, *Adult periodical cicada;* 4, *Adult dog-day cicada;* 5, *Larva of* Papilio asterias *on celery.*

PLATE XXIII.—1, *Hut or chimney of cicada;* 2, *Sound producing organ of male cicada;* 3 and 4, *Injury caused by egg-laying of cicada.*

(Figs. 2 and 4, enlarged.)

PLATE XXIV.—*Adult periodical cicadas.*

PLATE XXV.—*Female cicada depositing eggs.*

PLATE XXVI.—*Palmer worm:* 1, *Egg;* 2, *Injury to young apples;* 3, *Pupa;* 4, *Moth;* 5, *Injured leaf, with attached pupae;* 6, *Typical wing;* 7, *Wing variations.*

(Figs. 1, 3, 6 and 7, enlarged; 2, 4 and 5, natural size.)

PLATE XXVII.—*Work of palmer worm on apples.*

(Enlarged.)

PLATE XXVIII.—*Palmer worm in partially completed retreat.*

(Enlarged.)

PLATE XXIX.—*White grubs feeding at root of an aster.*

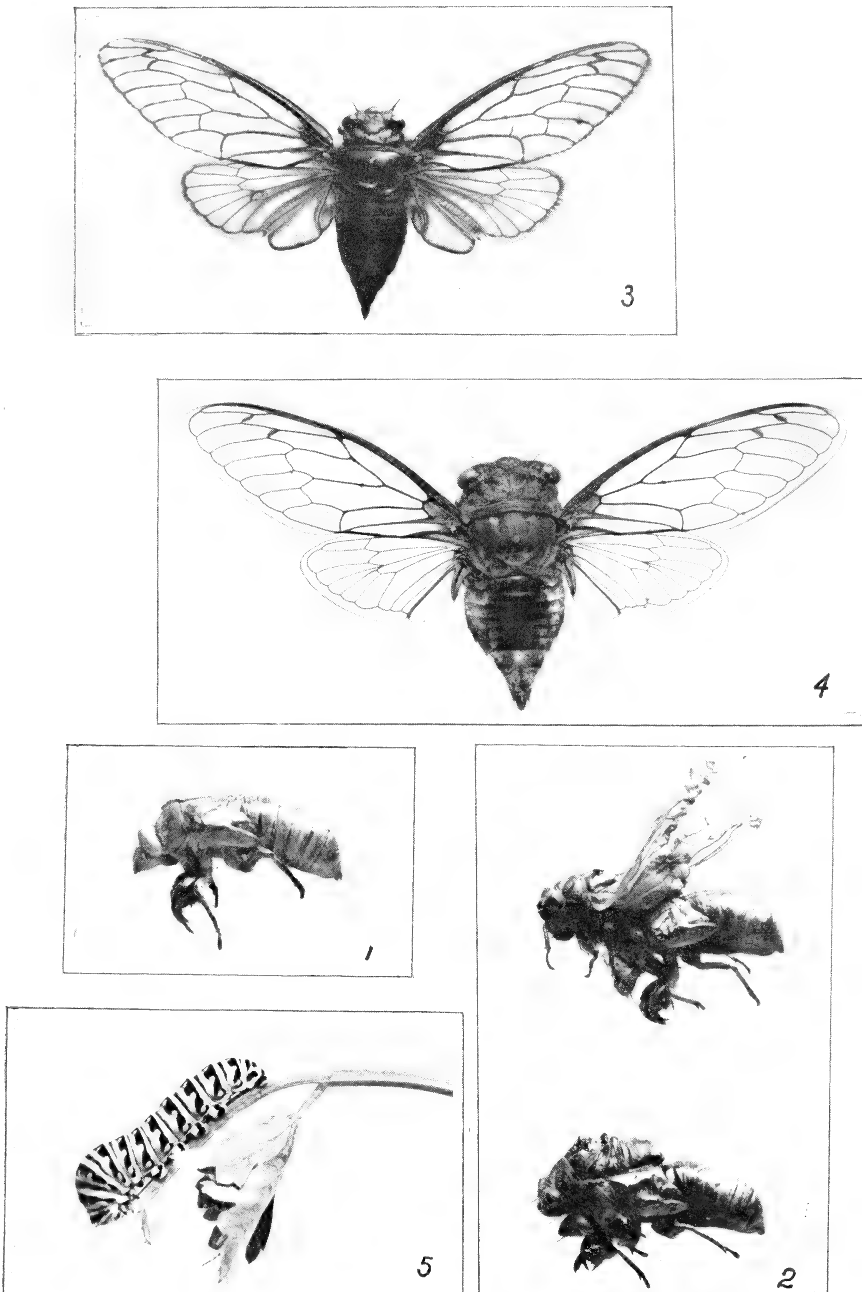

PLATE XXII.—PERIODICAL CICADAS AND PUPA CASES, DOG-DAY CICADA, AND LARVA OF *Papilio asterias.*

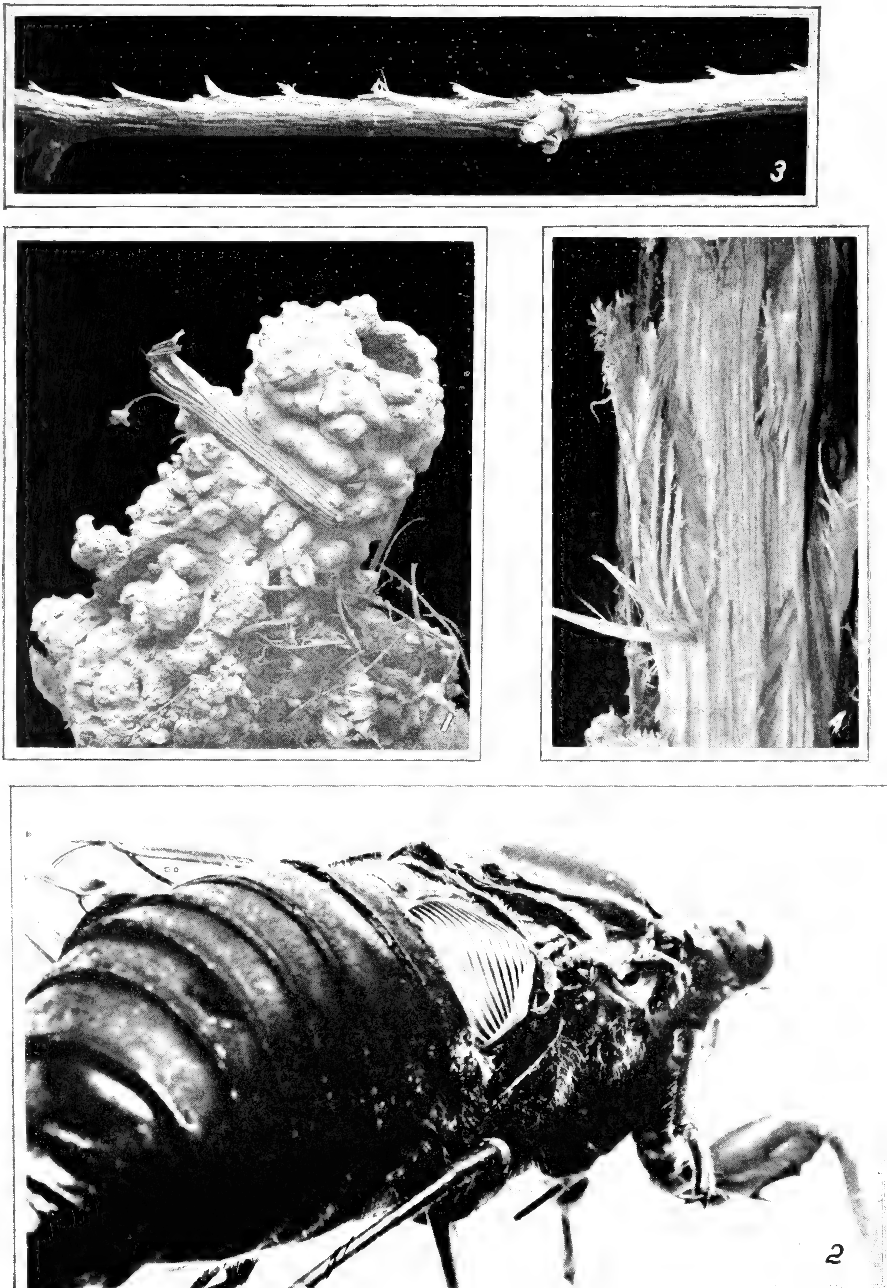

Plate XXIII.—Some Characteristic Details of Periodical Cicada and its Work.

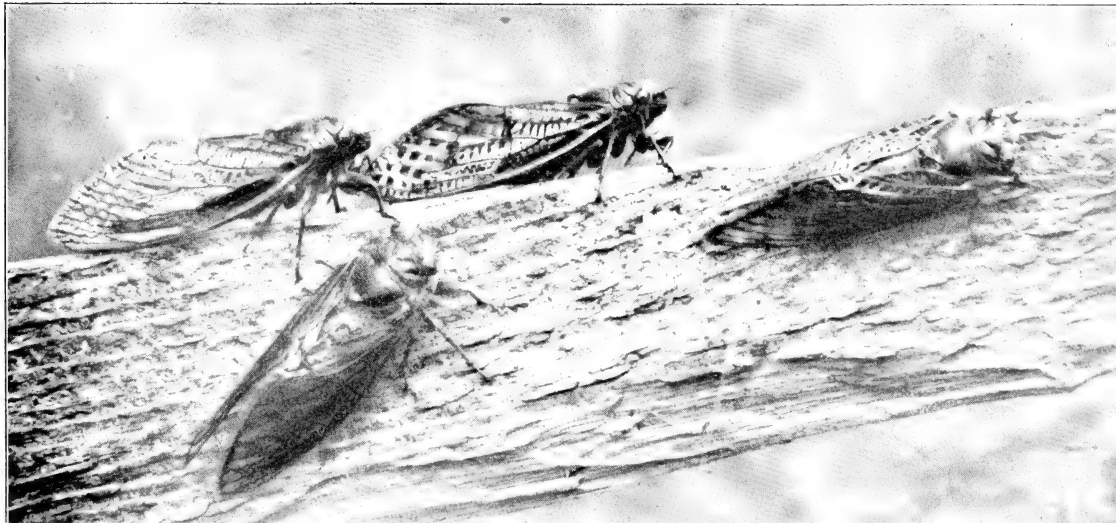

Plate XXIV.—Adult Periodical Cicadas.

Plate XXV.—Female Cicada Depositing Eggs.

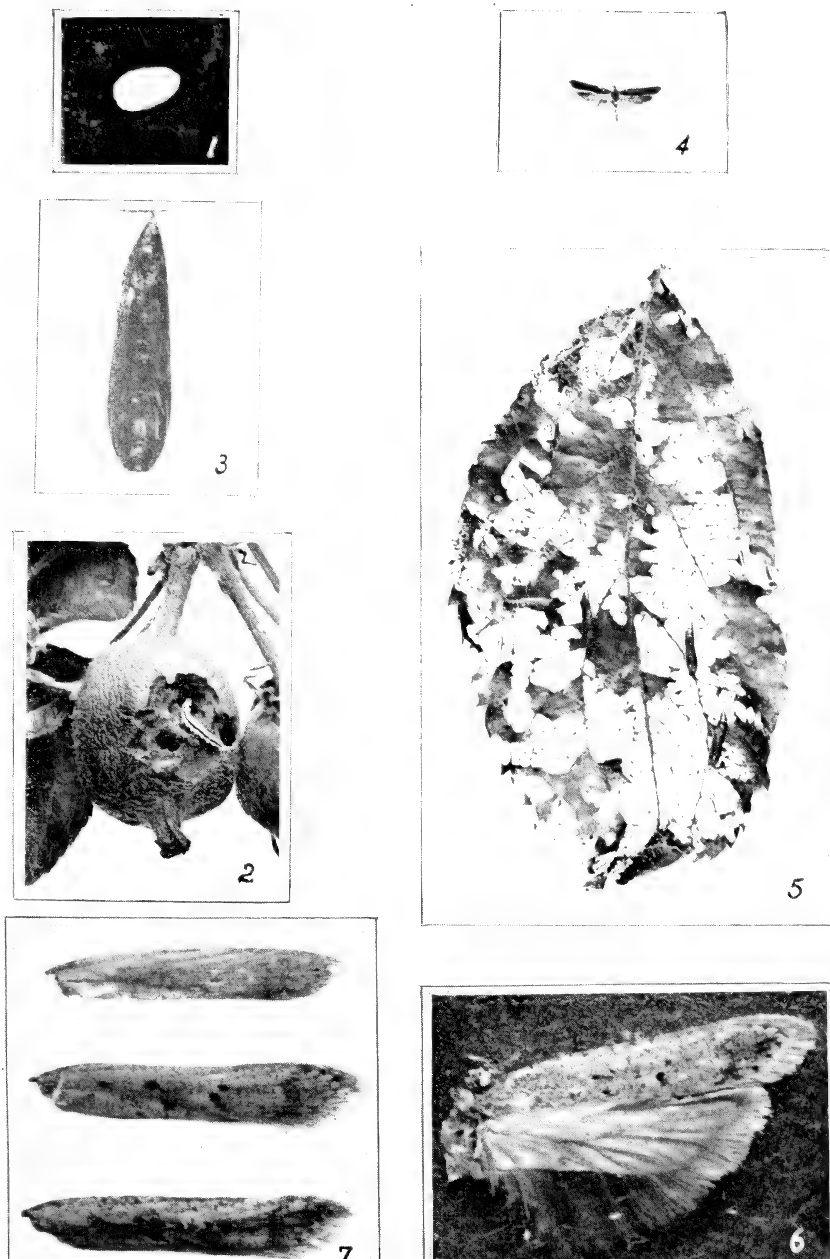

PLATE XXVI.—SOME CHARACTERISTIC DETAILS OF THE PALMER WORM AND ITS WORK.

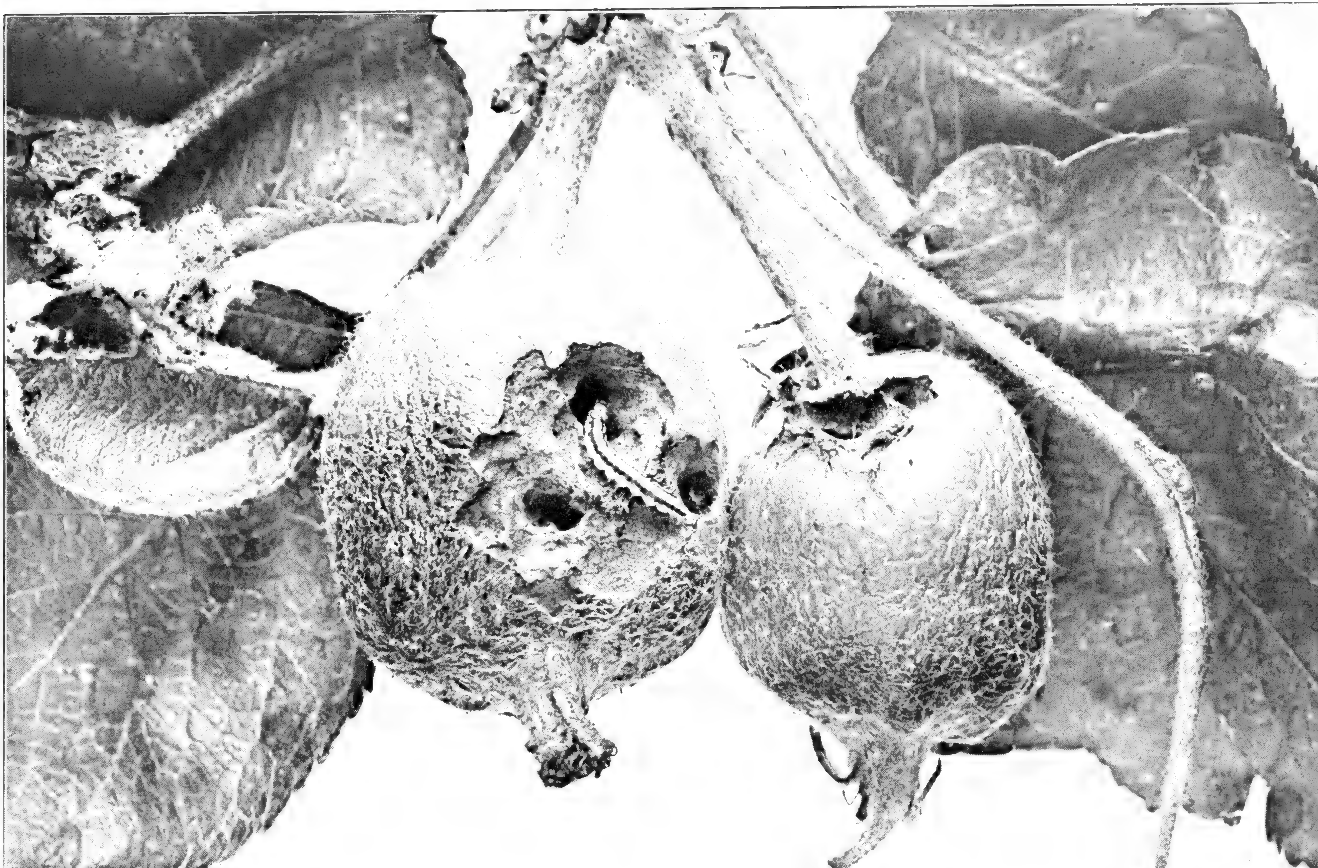

Plate XXVII.—Work of Palmer Worm on Apples.

Plate XXVIII.—Palmer Worm in Partially Completed Retreat.

PLATE XXIX.—WHITE GRUBS FEEDING AT ROOT OF AN ASTER.

flooded for several years, apparently without injuring the cicadas which were found from 12 to 18 inches below the surface.[10]

Habits of the pupæ above ground.—When ready to abandon the subterranean life the pupæ dig upward toward the surface of the ground. They always emerge in the spring, usually, in this climate, about the middle of May, although the time probably varies somewhat with the season. The individuals in a given locality usually come out of the ground at about the same time, not more than three or four days elapsing between the appearance of the first and last individuals. Most of them come out during the night, but occasionally stragglers appear during the early morning hours.

The pupa when it first appears above ground is soft bodied and creamy white in color. It may move about actively for a short time, probably a few hours, although often less, in search of a suitable support which it can climb and cling securely to. The skin hardens rapidly, and after the insect has found a suitable place and is prepared for the change, splits down the back and the adult escapes, leaving behind the empty pupa skin, Plate XXII, Fig. 1. It is not uncommon to find these old pupa cases attached to the leaves or twigs several weeks after the adults have escaped. Some idea of the manner in which the adult escapes from the pupa skin is given by Fig. 2, where two adults are seen which only partially succeeded in freeing themselves. The upper one succeeded in freeing its head, thorax and both wings while the lower has but its head and thorax free.

Height to which the pupæ climb.—The pupæ usually do not climb far. The old skins from which the adults escaped will usually be found from a few inches to from five to ten feet above the ground. A comparatively small number may succeed in going much higher. In one instance the writer found the pupa cases nearly thirty feet above the ground attached to the limb of a tree, and in a few cases several were found at about twenty feet.

[10]Idem., p. 93.

Building huts.— Under some circumstances not yet well understood the pupæ build chimney-like huts on the surface of the ground just before abandoning the subterranean life. These huts may open at the top or be closed at the top and open at the sides. The hut is in reality a continuation above ground of the channel in the earth made by the pupa. Plate XXIII, Fig. 1, shows a hut, natural size, that opens at the top. In some cases large numbers will be built and in others but very few. They are built on both high and low ground, as instances are recorded where they have been found in both localities. That a preference may sometimes be shown is not improbable. A case in point was observed by the writer at Union Springs during the spring of 1899 when the cicadas appeared in large numbers in that locality. The pupæ emerged in greatest numbers in a grove which was on both high ground and low swampy land. Although careful search was made the huts could be found only on the low wet land although as many or more cicadas had emerged from the higher ground.

The adult.—When it first emerges from the pupal skin the adult insect is soft bodied and creamy-white in color. But the integument soon hardens, and as it does so turns jet black. The eyes and wing veins are coral red. The body of the female measures about one inch in length. The wings, which are membranous, form a roof over the body when at rest, projecting beyond it about half an inch. When expanded they measure about three inches from tip to tip. Plate XXIV, which is from a photograph from life, shows a number of cicadas natural size. At Fig. 3, Plate XXII, an adult female with wings spread is shown.

The adult cicadas are active, noisy creatures, flying about during the day and making the woods ring with their shrill song. Their flight is very short and hence, as they do not migrate in the immature stages, the species spreads very slowly.

Song of the periodical cicada.— The so-called song of the periodical cicada is produced by the males only. Each male has two song-producing instruments, one on either side of the basal segment of the abdomen, underneath and concealed by the wings,

They are quite complex but each consists principally of a corrugated ear-like drum which, controlled by a powerful muscle, may be made to vibrate rapidly. Plate XXIII, Fig. 2, is from a photograph showing one of the drums greatly enlarged. The song is usually produced in unison and is shrillest during the heat of the day. The warmer the sun the louder the song becomes. The locusts seem to be especially sensitive to sunlight and heat, as was well illustrated in the writer's experience at Union Springs, June 14, 1899. The day was windy with heavy fleecy clouds which frequently obscured the sun. While the sun was shining brightly, along the margin of the wood where the locusts were most numerous, they were very active, flying frequently into the air and making an almost deafening noise. As soon, however, as the sun was obscured by a cloud there was a decided lessening of activities and a lull in the song, which would almost cease if the sun was hidden very long. It is unusual for the cicadas to sing during the night, but instances have been recorded where the song has suddenly broken out long before daylight, but to last for a few minutes only. The song has been analyzed by Dr. C. V. Riley and others and found to consist of three distinct notes.

Injury caused by the periodical cicada.— Contrary to the belief held by many, the adult cicadas eat little or nothing. If any nourishment is taken it is by the female only, and it is doubtful if she, except in very rare instances, takes food. As previously stated the larvæ and pupæ feed underground on the sap from the roots of trees, shrubs and vines, but so little is required for their slow growth, that except in occasional instances where they are unusually abundant, it is not probable that appreciable injury is done. The important injury is caused by the females in laying their eggs in the twigs. Frequently the twigs and smaller limbs are so weakened by the punctures of the female as to break off with the slightest wind. Large trees may withstand this injury without serious consequences, but small trees of a few years' growth are often seriously injured.

The extent to which young trees may be injured was well illustrated along the western shore of Seneca Lake during the spring of 1899. In one orchard in the vicinity of Earls, several young plum and cherry trees were badly broken as a result of the punctures of the females. Another case near Dresden was that of a small vineyard in which the cicadas appeared in large numbers. When seen by the writer, June 9, nearly all of the vines were badly broken and in most cases the new growth wilted. An examination showed that the cicadas had selected the growth of the previous year in which to deposit their eggs, thus causing the new growth to wilt and finally die. As a result of the attack this vineyard produced very little fruit that year. Old wounds caused by deposition of the eggs afford lodgment for other insects, especially the woolly aphis, thus resulting in a secondary injury which may be of a serious nature.

How the eggs are deposited.— The eggs are deposited in the twigs of both fruit and forest trees and of vines. In fact all kinds of trees are attacked except evergreens. At Plate XXV, which is from a snap shot from life, a female is shown, natural size, in the act of depositing her eggs in the branch of a young apple tree. She is enabled to place her eggs within the twig by means of her sharp ovipositor. This is a very strong instrument of a tough horny substance. It is spear shaped and consists of three pieces, the support or back piece and two lateral blades which slide up and down upon it and which have saw-like teeth on the edges. When ready to deposit eggs the female slowly forces her ovipositor into the twig, splintering the wood and placing the eggs at a slight angle close together and in double rows. The two converging double rows are deposited at one time. It has been estimated that a single female will lay from 300 to 600 eggs. The external evidence that eggs have been deposited is made very plain by the bits of splintered wood that project above the surface of the bark as shown at Plate XXIII, Fig. 3. Fig. 4 is from a photomicrograph showing the twig much enlarged, cut open lengthwise exposing part of one row of eggs. The period of incubation usually varies from about six to seven weeks.

SUMMARY OF LIFE HISTORY.

The periodical cicada lives in the ground during most of its life. The seventeenth year in the north and the thirteenth year in the south pupæ appear above ground. The winged adults escape in a few hours. Their life is short, probably varying from about two to three weeks. Eggs are laid in the twigs of deciduous trees, shrubs and vines. They hatch in six or seven weeks. The young drop to the ground and work their way into the soil. They feed upon the sap from the roots, which they secure by inserting their beaks into the bark. They probably move but little, but live in a cell of earth just large enough to accommodate their bodies. The larval and nearly all the pupal life is passed in the ground. Slight injury may be caused by sucking the sap from the roots, but the principal injury results from depositing the eggs in the twigs.

BROODS.

Two distinct races.— Two distinct races of the periodical cicada are known, the seventeen and the thirteen-year races. The former is confined to northern temperatures and requires seventeen years to complete the life cycle, while the latter is confined to the south and requires but thirteen years.

Number of broods and distribution.— The number of broods was originally placed by Dr. Riley at twenty-two. Later investigations by Marlatt[11] resulted in his placing the number at thirty and renumbering all of the broods. The distribution is evidently confined to the United States east of the Rocky Mountains where the cicadas have been found in varying abundance in every State except Maine and New Hampshire.

An interesting table has been prepared by Marlatt giving the old and proposed enumerations of the broods. Of this table Mr. Marlatt[12] says: "The following table, beginning with 1893, when the initial broods of both the seventeen-year and thirteen-year series appeared in conjunction, illustrates the new nomenclature suggested, and in parallel columns also are given the

[11] U. S. Dept. Agr., Div. Ent , Bul. 18, n. s., p. 53.
[12] U. S. Dept. Agr , Div Ent., Bul. 18, n. s., p 54.

corresponding nomenclatures proposed by Professor Riley, by Walsh and Riley, by Fitch and the year records in Dr. Smith's register." The table is as follows:

NOMENCLATURE OF THE BROODS OF THE PERIODICAL CICADA.

Year	BROODS OF THE 17-YEAR RACE.					BROODS OF THE 13-YEAR RACE.				
	Proposed enumeration.	Riley numbers.	Walsh-Riley numbers.	Fitch numbers.	Smith register.	Proposed enumeration.	Riley numbers.	Walsh-Riley numbers.	Fitch numbers.	Smith register.
1893	I	XI	—	—	1842	XVIII	XVI	—	—	1854
1894	II	XII	VIII	1	1843	XIX	XVIII	XIII	3	1842-1855
1895	III	XIII	IX	—	1844	XX	II	—	—	1843
1896	IV	XIV	X	—	1845	XXI	IV	—	—	1844
1897	V	XV	XI	—	1846	XXII	VI	IV	—	1845
1898	VI	XVII	XII	7	1847	XXIII	VII	V	5	1846-1859
1899	VII	XIX	—	—	1848	XXIV	—	—	—	—
1900	VIII	XX	XIV	2–8	1849	XXV	—	—	—	—
1901	IX	XXI	XV	5	1850	XXVI	X	—	—	1849
1902	X	XXII	XVI	4	1851	XXVII	—	—	—	—
1903	XI	I	I	9	1852	XXVIII	—	—	—	—
1904	XII	—	II	—	1853	XXIX	—	—	—	—
1905	XIII	V	III	6	1854	XXX	—	—	—	—
1906	XIV	VIII	VI	3	1855	XVIII	XVI	—	—	1854
1907	XV	—	—	—	—	XIX	XVIII	XIII	3	1842-1855
1908	XVI	IX	VII	—	—	XX	II	—	—	1843
1909	XVII	—	—	—	—	XXI	IV	—	—	1844

OBSERVATIONS IN WESTERN NEW YORK ON THE BROOD OF 1899.

Distribution.— To ascertain the distribution of this brood in the State a number of localities where the adults were abundant were visited. Reliable information was also received from other points and it was finally ascertained that the cicadas had appeared in the following localities: In *Monroe Co.,* on the north-east shore of Irondequoit Bay, and in the vicinity of Webster; *Livingston Co.,* Geneseo and Sonyea; *Ontario Co.,* Manchester, Victor, Padelfords, Farmington, Bloomfield, East Bloomfield and Billsboro Station; *Yates Co.,* Earls, May's Mills and Dresden and points between; *Cayuga Co.,* Union Springs and points extending about three miles north, three miles west and seven and one-half miles south; *Madison Co.,* Chittenango and vicinity; *Onondaga*

Co., Syracuse, Onondaga, and points south in the Onondaga Valley. Doubtless there are many other localities in the State where this brood appeared that are not mentioned here.

According to Marlatt[13] this brood also occurs in Wyoming Co., and in Pennsylvania in Allegheny and Washington counties.

Date of first appearance.— The earliest date of the appearance of the adults of this brood which we have was June 1, when a few appeared near Victor, Ontario Co. But few emerged, however, until June 4, when they appeared in swarms, increasing in numbers during the following two or three days. On June 9, the females were depositing eggs. Egg laying was continued actively during the following week and was observed as late as June 19. June 20 they had almost entirely disappeared.

Localities in which the locusts were most abundant.— The swarms of locusts were confined largely to woodlands and old orchards. Here and there a few appeared in cultivated fields, indicating that in previous years they had covered wider areas but had been reduced in numbers, probably by the cultivation of the soil. In the localities along Seneca and Cayuga lakes, especially the former, where the brood appeared, the local distribution was sharply marked. They were found very largely in the wooded gulleys along the lake and in the orchards bordering them. In a few instances they were also found in groves on high land.

Evidence that the brood is decreasing in numbers.— Evidence that the brood is decreasing is furnished by its history. A number of old residents state that the locusts were less abundant in 1899 than 17 years previous. In the vicinity of Earls and Dresden two old residents remembered them 34 years previous to 1899 and one 51 years previous to that date. During the memory of these men the cicadas have become greatly lessened in numbers. The two previous swarms had appeared over much wider areas, extending from the lake back to the top of the hills, while the only areas occupied by the last swarm were back from the lake, and, as previously stated, confined largely to the gulleys.

[13] U S. Dept. Agr., Div. Ent., Bul. 14, n. s., p. 32.

OTHER EXPECTED BROODS.

History and distribution of 1902 brood.— The brood due to appear in 1902 (Brood X of Marlatt's enumeration, XXII of Riley's enumeration) is one of the largest, if not the largest, of the 17-year broods. In this State it is located in Niagara, Monroe, Kings and Richmond counties. The exact distribution in this State is probably not known. As it is of importance to ascertain its limits, and especially the localities where the adults appear in greatest numbers, the writer will be especially glad to receive information from those who observe them this spring as to the time, numbers and localities in which they appear. This brood also occurs in the following states: Alabama, Delaware, District of Columbia, Georgia, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia and Wisconsin.

Other broods in New York State.— Brood XIV[14] (VIII) due in 1906 is located at points on the eastern half of Long Island. Also throughout the District of Columbia, in Georgia, Illinois, Indiana, Kentucky, Maryland, Massachusetts, New Jersey, North Carolina Ohio, Pennsylvania, South Carolina, Tennessee, Virginia and West Virginia. Brood II (XII) due in 1911 is located over a wide area in eastern and southeastern New York, extending the entire length of the Hudson River Valley and north into the Lake Champlain region, including the following counties: Albany, Dutchess, Greene, Queens, Suffolk, Richmond, Orange, Putnam, Rensselaer, Rockland, Saratoga, Ulster, Washington and Westchester. It also occurs in the following states: Connecticut, New Jersey, District of Columbia, Maryland, Virginia, North Carolina, Pennsylvania, Indiana and Michigan. Brood VI (XVII) which appeared in Richmond and Westchester counties in 1898 will be due again in 1915. It is known to occur also in Illinois, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Virginia, West Virginia and Wisconsin. Brood VIII (XX) is due in 1917. It is not positively known whether any portion of this brood is located in this State or not,

[14]Marlatt's enumeration; numbers in parenthesis Riley's enumeration.

but if so in the extreme western part of Chautauqua County only. It is located in Massachusetts, Ohio, Pennsylvania, West Virginia and possibly Illinois and South Carolina.

METHODS OF CONTROL.

Protection.—When occurring in large numbers, there seems to be no practical method of controlling the adults except over very small areas. Experiments with pyrethrum, kerosene emulsion and various acids have shown that all of these substances have some effect but are probably of little practical value. Small trees, shrubs and vines can be protected from the adults by covering them with sheeting or some similar material or with wire netting. This, of course, would be practical only in the case of a few choice plants. As a means of reducing the numbers of a brood in any locality the pruning of branches in which eggs have been deposited if taken in time will prove effectual. The injured branches should be cut out soon after the eggs are deposited. As a further precaution against injury by the adults, young stock should not be planted during the two years previous to their appearance in those localities where the insect is known to occur.

Natural enemies.[15]—A number of parasites attack the periodical cicada including some interesting mite parasites of the eggs. A species of digger wasp is also known to attack the adults. A number of birds also feed upon them. Among birds the English sparrow is said to be their greatest enemy. Chickens will also feed upon them. In one case reported to the writer a hen was observed to devour fourteen in quick succession. Fox squirrels and ground squirrels have been observed feeding upon them. In cases where the cicadas fell into the water blue cat fish, black bass and white suckers have been known to feed upon them. A fungus disease also attacks the adults.

DOG-DAY CICADA.

A related species often mistaken for the periodical cicada.—A species which is often mistaken for the periodical cicada is known as the dog-day cicada or harvest fly, *Cicada tibicen* Linn. It

[15]For an extended account of the natural enemies of the periodical cicada see U. S. Dept. Agr., Div. Ent., Bul. 14, n. s., pp. 95–107.

requires but two years to develop; and as there are two broods the adults appear every year. This species is larger and the body is more wedge-shaped than the other. Its black and green color and the powdered appearance on the under side of the body also easily distinguish it from the smaller species. The song is a high sharp trill, most commonly heard about mid-day. Plate XXII, Fig. 4, shows a dog-day cicada with its wings spread.

II. THE PALMER WORM.

During the spring of 1900 many of the apple orchards of western New York became overrun with a small, active caterpillar popularly known as the palmer worm and scientifically as *Ypsolopus pometellus* Harr. It was most abundant in Erie, Niagara, Orleans, Genesee, Monroe, Ontario, Wayne and Cayuga counties. The history of the insect shows that it has appeared in large numbers only after long periods of years, and that it usually disappears as suddenly as it comes. We were, therefore, much interested to know whether the insect would be true to its record and disappear this time as quickly as it came. Accordingly, we took pains to ascertain whether it had again appeared in numbers during the past season but were unable to locate an orchard in which it was abundant. As was to be expected, however, an occasional one could be found, and rarely a tree would contain quite a large number, showing that some agency or agencies, probably climatic, had prevented the development of a large percentage. Whether it will remain reduced in numbers for another long period of years remains to be seen.

Food plants and nature of injury.— It is probable that this species has a large variety of food plants. Fitch,[16] recording an outbreak in 1853, considered the oak and the apple the most seriously injured, but adds that " all other trees and shrubs were more or less infested with the worms at this time." Of the fruit trees the apple is evidently preferred although the caterpillars are known to feed upon the plum and cheery.[17] The writer has observed them in a few instances feeding upon the pear.

[16]Noxious Insects of New York, p. 224.

[17]Harris, T. W. As quoted by Slingerland in Cornell Univ. Agr. Exp. Sta. Bul. 187, p. 89.

When attacking fruit trees the caterpillars feed upon both leaves and fruit, skeletonizing the former and eating irregular holes in the latter. (Plate XXVI, Figs. 5 and 2.) The injury to the fruit is quite characteristic. A shallow area is eaten out on one side and sometimes over a considerable portion of the fruit, from which one or more deep channels lead into the interior. Plate XXVII shows the characteristic injury to a young apple. The caterpillar is about to enter the channel. Favorite fruits for the caterpillars to work upon are those that hang so as to touch each other. In such cases the shallow area is often eaten out on both fruits and a deep channel made into each so that the caterpillar can pass from the interior of one directly into the interior of the other. In some cases very small apples may have nearly all the interior eaten away, the injury much resembling that of the green fruit worms. The result of such injury is to prevent the development of the fruit or cause it to become distorted.

DESCRIPTION AND NOTES ON LIFE HISTORY.

The egg.— The egg-laying habits of the females have remained a mystery. So far as we have been able to ascertain there is no record of where the eggs are laid and no description of the egg. With the hope of securing some of the eggs a large number of moths were kept in confinement. No eggs were secured except in two instances. The moths that laid these eggs were kept in small glass bottles with a single apple leaf that had been carefully examined before being placed in the bottle. After a few days two eggs were found on one leaf and one on another. They were stuck lightly to the surface and were easily jarred off. Two were placed on the upper and one on the under surface. None of the eggs hatched. In color they were pearly white, oblong-oval in shape, obtusely rounded at one end and tapering slightly toward the other. The shell was quite delicate and easily broken except at the smaller end where it was thickened. They were about uniform in size and measured .36 mm. by .16 mm.

The failure to secure eggs from the other moths and the fact that these eggs did not hatch, indicate that the conditions under

which they were secured were not normal. It is not improbable, however, that eggs are occasionally laid during the summer by the adults of the spring brood, as occasional young and full-grown larvæ were found by the writer late in August and on September 19. Some of the young larvæ taken in September measured less than one-quarter inch, indicating that they had recently hatched. Adults were found on the former date but none on the latter. Although careful search was made but few larvæ were found, and these were scattered in several trees. The occurrence of the larvæ at this time of year means one of two things, either that they belong to a second brood or that there may be a great delay in the time of egg-laying among certain individuals that probably lay their eggs normally in the spring. The former seems to us the more probable as it would not be unnatural, while so long a delay in either egg laying or the development of the egg would seem to be extreme.

Although the life history of this insect is not yet well understood it seems probable from the time the larvæ appear and the fact that the adults have been kept alive until late in October,[18] that the eggs are laid in the spring by the moths which have lived in some protected place during the winter.

The larva.— The larvæ or caterpillars appeared early in June. Individuals kept in our breeding cages were about three weeks in reaching maturity. They are very active when disturbed, violently jerking and wriggling the body and often dropping suddenly from the leaf or fruit and suspending themselves in the air in the same manner as the canker worms. On the leaves they make sheltered retreats for themselves by drawing over the edge of a leaf and fastening it by silken threads or by spinning a covering of silk over a depression in the leaf. At Plate XXVIII a caterpillar is seen in a partially completed retreat. Not infrequently these retreats are abandoned without being completed. They also often draw two or three leaves together making a nest after the manner of the larva of the bud moth. The soft parts of the leaves in the immediate vicinity of these hiding places are eaten, until finally it is necessary to seek food elsewhere, when new shelters are constructed. When alarmed

[18]Slingerland. Cornell Agr. Exp. Sta Bul. 187, p. 95.

the caterpillars will often seek one of their retreats if near to it. The following manuscript notes by Mr. P. J. Parrott, who studied the insect in the Huntress orchard at Manhattan, Kansas, are interesting in furnishing additional data on the habits of the larva.

"The amount of damage that this insect can do is remarkable. In some instances it will eat all of the leaf as far as it is feeding, while in the majority of cases it will consume the pulpy parts of the foliage, leaving in many cases nothing but the larger veins, ribs and stem of the leaf. The insect in the larval stage does not always feed exposed, but generally has more or less of its body protected by a case formed from an apple leaf or, in the commencement of the building of a new case, it hides in the bottom of an enfoldment of a leaf, protected by a silken roof of its own manufacture. The insect commences the folding of a leaf in any of the following ways: First, when the upper surface of the leaves forms a concavity the larva will commence its work along the main rib. It lies parallel with the rib, and swings its head from side to side alternately, now frontwards and now backwards, attaching each time to the sides of the leaf a fine thread till a coarse network of silken threads is formed; second, on the lower surface when the lateral edges of the leaf are folded in towards that side; third, when any part of the leaf is turned or inclined to turn on itself, the larva will seek such a hollow, and draw the edge of the leaf over itself after the manner of first and second cases; fourth, when a leaf is in contact with another or overlaps within a short distance, the two are connected by the silken threads.

"As soon as it is hatched the larva commences to construct coverings after the manner described. Whatever the covering may be it leaves one or more apertures through which it may project a part of itself or sometimes entirely emerge to eat. When the covering or case is just formed the larvæ seem to prefer the parts of the leaf adjoining the case, but when this is devoured they commence to eat the pulpy parts of their case, and possibly do eat more or less of this from the very beginning, but more so when they have devoured most of the leaf. When the greater part of a leaf is destroyed and nothing remains of

their case but the veins and silken threads they abandon their case, crawling to some more removed spot, all the time moving hither and thither as if using some sense of discrimination till a suitable leaf is found. At other times they drop down with a web to leaves below; they may crawl to the end of a twig and eat into the terminal part; while in some instances, having eaten the greater part of the leaf, they will commence to work on the stem of the leaf, which in some cases they have severed, thus either precipitating themselves to the earth together with the leaf, whereon they commence to crawl for that or another tree; or, falling upon a branch below they then pass to other leaves.

"Larvæ at different parts of the day are to be found either outside of their cases, on the same or opposite side of the leaf, or just projecting out their heads from one side or the other of their cases within a short radius. The adults of these larvæ were kindly identified by Dr. C. H. Fernald."

The full grown larva measures about one-half inch in length. It is slender and tapering in shape. The color of the body varies from a flesh color to a sulphur-yellow tinged with green, or more decided greenish tints. The head and shield vary from light yellowish brown to dark brown. The legs and prolegs are yellowish to yellowish brown. The most prominent markings of the body are three broad dark lines extending the full length of the dorsum. The middle line may be divided longitudinally into two finer ones. This line is usually lighter than the others. The body is sparsely covered with fine hairs which arise from small black dots.

The pupa.—When about to pupate the larva attaches itself usually to a leaf, but not infrequently to the fruit or twig. (Plate XXVI, Fig. 3 enlarged; Fig. 5 shows an injured leaf, natural size, with pupæ attached.) Most of the pupæ found by the writer in the orchards were attached to the leaves. They measure about one-quarter inch in length and are reddish brown to dark brown in color. The pupa stage probably lasts about 8 to 10 days as a rule, as a large number of individuals in confinement averaged about this number. Slingerland[19] states that in their cages

[19]Cornell Agr. Exp. Sta., Bul. 187, p. 94.

"Many pupæ were found naked on the surface of the soil, and others in a slight silken web just beneath the surface of the soil." The majority of the pupæ are probably formed late in June.

The adult.—The adults appear during the last days in June or early in July. Most of those under our observation emerged during the first ten days of July. They are small active moths that fly toward dusk or at night, hiding during the day in any convenient retreat. They measure about three-eighth inch in length and about one-half inch from tip to tip of the expanded wings. They rest with the anterior part of the body well up. The color is slate or ash gray, often with a brownish tinge. The fore wings are marked with small dark spots. Four larger ones are readily distinguished near the middle and sometimes one near the base. A dark patch or broad line marks the tip which is also bordered with small black dots. These dots may extend along the anterior and posterior margins, either one or both. The posterior wings are dusky colored with a steel blue, or as Slingerland[20] has described it, an azure blue reflection. They are heavily fringed. (Plate XXVI, Fig. 6; and Fig. 7, middle figure.) The joints of the antennæ are alternately dark and light. Plate XXVI, Fig. 4, shows a moth natural size with wings expanded.

The variations in the markings of both larvæ and adults have resulted in the same species being described under different names.[21] Fitch[22] describes six varieties based on the markings of the wings. Three variations from the typical form (Plate XXVI, Fig. 6) are shown at Fig. 7. The two lower wings do not seem to come under any of Fitch's varieties, but the lower one was supposed by him to belong to a distinct species. Slingerland[23] retains this as a variety.

From the published accounts of this species it appears that the life of the adult is not yet well understood. It seems probable, however, that the species hibernates in the adult stage.

[20]Cornell Agr. Exp. Sta., Bul. 187, p. 85.

[21]For synonomy of this species see Slingerland's list in Cornell Univ. Agr. Exp. Sta., Bul. 187, pp. 100-101.

[22]Fitch. Noxious Insects of N. Y., 2d Report, p. 229.

[23]Cornell Agr. Exp. Sta., Bul. 187, p. 85.

The facts that the adults have been kept alive in breeding cages until late in October, see p. 250, and found active in the orchards late in August furnish evidence strongly indicating that the adults live over winter.

SUMMARY OF LIFE HISTORY.

The caterpillars appear in June and feed upon both leaves and fruit. In about two weeks they are full grown. The chrysalis is naked and found in secluded places in the injured leaves or upon the bark or under rubbish, or in the grass under the trees. The adults appear in about ten days. It is probable that they hibernate, making but one annual brood. Young larvæ found in September indicate a partial second brood. Little is known of the egg laying habits. It is a natural supposition that they are laid in the spring on the twigs or leaves.

METHODS OF CONTROL.

The sudden appearance and equally sudden disappearance of this insect have given practically no opportunity for experiment with remedies. But as the caterpillars feed openly on the leaf tissue, spraying with arsenical compounds would without doubt prove effectual. During the outbreak of this insect in 1900 it was very noticeable that the orchards that had been sprayed were comparatively free. One case especially, that came under the writer's observation, illustrated this. This orchard had not been sprayed that season, and was overrun with the insects. Two other orchards in the neighborhood that had not been sprayed were also infested while the sprayed orchards were in every case practically free.

III. WHITE GRUBS ATTACKING ASTER PLANTS.

The larvæ of the May beetle, *Lachnosterna fusca* Fröh., and allied species feed upon the roots of a large variety of plants. The adults or beetles feed upon the leaves of a variety of trees and shrubs. In western New York nursery stock, especially young fruit trees, is often seriously injured. The grubs of the

species above referred to are evidently the most numerous and consequently do the most damage. They feed upon the roots, often eating the main root nearly off.

The field of asters that was injured by the grubs is located on the outskirts of Geneva. It contained about 20,000 plants of several varieties. The soil was principally sandy loam. The year previous a crop of nursery trees had been removed from the field. The aster plants began to show injury from the work of the beetles about the middle of July. The injured plants began to wilt suddenly and soon died. Examinations made during the latter part of July showed about ten per ct. of the plants injured. Later a few more plants were destroyed by the grubs, making the percentage of injured plants somewhat higher. The grubs were usually found feeding at the crown of the root and for a short distance above. Plate XXIX shows two grubs, natural size, feeding. In every case the bark had been eaten off all the way around the stem and in many cases the stem was completely severed. From one to four grubs were found at each plant.

The grubs were all nearly full grown and hence were in their second year. If left undisturbed they would have emerged as beetles the year following. The eggs were laid in the ground during the spring of the year previous and the young grubs were evidently supplied with food by the roots of the nursery trees. The removal of the trees took this food away from them, which meant that the crop that followed the next year would be sure to be injured by them.

No attempt was made to revive the injured aster plants, but as soon as one was observed to be wilting it was dug out and the grubs destroyed. By going over the field every day for about a week during the middle of July large numbers of the grubs were killed; probably most of them, as there was but comparatively little injury later. White grubs are difficult to check after a field has become infested. Prevention is by far the most satisfactory. If land is left in meadow for several years it is more apt to become seriously infested than if a short rotation of crops is practiced.

IV. *PAPILIO ASTERIAS* ATTACKING CELERY.

The larva of this species is popularly known as the celery caterpillar and in some localities the parsley caterpillar. It is known to feed upon a variety of plants of the family *Apiaceæ* (*Umbelliferæ*) among which are parsnip, parsley, dill, fennel, anise, caraway and carrot. In the celery growing section the caterpillar sometimes become quite abundant. During the spring and summer of 1900 and 1901 they were quite numerous in the vicinity of Geneva. They were especially noticeable on young celery plants in the seed beds, where they were sufficiently numerous to require attention every day.

The newly hatched caterpillars are nearly or quite black, with a white band about the middle and one toward the posterior end of the body. By the time they have become full grown they have changed to a pea-green color with a black band on each segment. In each of these bands are four orange-yellow spots, two on each side. Plate XXI is from a photograph, from life much enlarged, of one of these caterpillars nearly full grown. It was feeding on the celery stalk just before the picture was taken, but was induced to stop for a moment by a gentle jar of the stalk, when it assumed the attitude shown in the picture just long enough to be photographed. The same caterpillar is shown natural size at Plate XXII, Fig. 5.

The adult is one of the well known "swallow tail" butterflies. Both the males and females are black, with sulphur-yellow and steel-blue markings. The former has two bands or rows of sulphur-yellow spots crossing the wings on the outer half, between which are flecks or spots of blue. On the inner angles of the hind wings are eye spots nearly or quite surrounded by red. The female is less prominently marked with the sulphur-yellow spots but the blue spots are more prominent.

The insect lives over winter in the chrysalis stage. The adults appear in May or early June and soon begin to lay eggs on the leaves, usually on the under surface of the plants that are to furnish food for the caterpillars. They hatch in about ten days. The young caterpillars feed voraciously and increase in size rapidly. In about two weeks they are full grown and seek a

sheltered place in which to form the chrysalis. Often the chrysalis will be found on the under side of the leaf upon which the caterpillar has been feeding. The adults emerge in from ten days to two weeks. Eggs for the second brood are soon laid. The chrysalids of this brood remain until the following spring before the adults appear.

The caterpillars are seldom sufficiently numerous to cause serious injury, but if abundant they are usually held in check by jarring from the infested plants or handpicking. Spraying with paris green or other arsenical compounds, where practical, is an effectual method of destroying them. If paris green is to be applied, use one pound to each 150 gallons of water with the addition of enough freshly slaked lime to make the mixture somewhat milky in appearance.

TREATMENT FOR SAN JOSE SCALE IN ORCHARDS. II.*

SPRAYING WITH KEROSENE AND CRUDE PETROLEUM.

F. A. SIRRINE.

SUMMARY.

The results of these tests, considered in connection with others previously reported by this and other stations, appear to indicate that spraying with kerosense or crude petroleum is safe and effective under the following conditions:

In using kerosene, only the best grades should be employed, as the lower grades are very liable to injure the trees.

Mechanical mixtures ranging from 15 to 25 per ct. can be used on apple and pear while the trees are in full leaf with but slight injury to the trees; while mixtures of even less strength are liable to cause some injury to stone fruits under the same conditions. Such dilute mixtures appear to be of value only against young insects unprotected by scales.

A good grade of kerosene can apparently be applied to large, vigorous pear and apple trees while they are completely dormant and cause little injury; but not to such trees after the sap begins to flow. With stone fruits, on the contrary, especially with peach, dormant trees suffer from even dilute mixtures, but even pure kerosene may be applied to such trees while the buds are swelling but are still unopened.

Peach and plum can be sprayed quite safely with 25 per ct. mechanical mixtures of crude petroleum (43½° to 44° Baumé, 0.79 sp. gr.) after buds commence to swell. If treated while dormant the trees are generally injured, often killed.

*A reprint of Bulletin No. 213.

It is unsafe to treat pear and probably apple with crude petroleum of the strength given, after buds have commenced to swell; but even 50 per ct. mechanical mixtures may be used on dormant apple and pear trees. Scale insects, even when fully exposed, were not all killed by a 15 per ct. strength of crude petroleum; though two applications of this strength were effective or one of the 25 per ct. strength.

INTRODUCTION.

As stated in Bulletin No. 209, conflicting results have been obtained from the various methods of combating the San José scale-insect. Consequently, it is a difficult matter to recommend any method and not have the recommendation opposed by negative results obtained in some other section of the country. For the most part, the conflicting results have been obtained in the use of coal-oil in some of its forms; although some such results have been secured when different experimenters have used the so-called "whale-oil soaps." In the latter case the diversity of results is probably due to the use of a soft soap in one case and a hard soap in another.

The tests given in the following report indicate that the diverse results obtained in using kerosene and crude petroleum by different testers can be accounted for by the lack of uniformity in time of making tests, in variety of trees treated, in grades of oil used, or in methods of application.

HISTORY OF STATION TESTS.

In Bulletin No. 194 of this Station results are given of careful tests in western New York, on dormant trees under nursery conditions, with two grades of kerosene, each undiluted and combined with different percentages of water; and in Bulletin No. 202, tests with crude petroleum in the same section are described.

The experiments here reported were made in southeastern New York at the same time as those noted in the bulletins just referred to. The same grades of kerosene and their mechanical mixtures were used on dormant trees under orchard conditions on Long Island; and, later, tests were also made with two grades of crude petroleum.

OBJECT OF TESTS.

The object of making these coördinate tests was to determine, if possible, some of the causes for the many uncertain and conflicting results in the use of kerosene and crude petroleum; and, at the same time, to compare the use of these oils with fumigation, especially as regards practicability and cost.

CONDITIONS.

All tests in the Second Judicial Department (on Long Island and in Westchester Co.) were made in the orchard. The trees were first sprayed, then pruned. The pruning was done after the spraying rather than before, as is the common practice, because nothing could be saved by pruning first; since just as much oil must be thrown, when using a Vermorel nozzle, to cover one small branch as to cover many. Furthermore, where crude petroleum was used, by first spraying and then pruning, untreated branches could be removed.

All applications were made by means of a Gould tripod "Kerowater" pump, and Gould Vermorel nozzles having the smallest aperture made. All oils were purchased of the Standard Oil Co.

In all cases where attempts were made to apply mechanical mixtures of oil and water of a certain percentage the mixture varied at least 5 per ct. each way. Thus, where we attempted to use 15 per ct., the amount fluctuated between 10 and 20 per ct.; between 20 and 30 per ct. for 25 per ct.; between 45 and 55 per ct. for 50 per ct.; and between 55 and 65 per ct. for 60 per ct. During the spraying at any given percentage and whenever the pump was changed from one percentage to spray a different one, it was tested to determine if it gave approximately the required proportion of oil.

TESTS OF OILS AS WASHES FOR SAN JOSÉ SCALE INSECT.

During the winter of 1899 and 1900, preliminary tests of two grades each of kerosene and crude petroleum were made. The tests were divided into two series. Of the kerosene tests, Series I consisted of 100° flash test ("distillate"), costing 12¼ cents

per gallon; while Series II consisted of 150° flash test ("water white"), costing 12¾ cents per gallon. Of the crude petroleums, that in Series I had a specific gravity of 0.837 (35° on Baumé oil scale) and was called "reduced oil or gas oil," costing 10¾ cents per gallon; that in Series II had a specific gravity of 0.795 (43½° on Baumé oil scale). This was called crude petroleum and cost 11 cents per gallon.

KEROSENE SERIES.

The following tables show the results from applying oil of different strength, at different dates, and on different varieties of trees. The effect on the trees is first given, then the effect on the insects; while the discussion summarizes, as far as possible, the results of Station tests and others of similar character. These tests were made in orchards at Cottage Gardens, Queens.

TABLE I.— EFFECT OF KEROSENE ON TREES, 1900.

SERIES I. 100° FLASH TEST ("DISTILLATE").

Trees sprayed Jan. 22. Clear, wind brisk, temperature 50° F.

Strength of oil.	Kind of tree.	Date of examination.	Effect on tree.
Per ct. 15	Apple.....	April 9	Slight discoloration of inner bark around buds.
		April 20	Apparently in good condition.
		May 23	Bark shows injury in spots.
		Oct. 12	Tree recovered.
	Peach.....	April 23	Part of branches injured.
		June 20	Tree one-half dead.
25	Apple.....	April 11	Trace of injury to inner bark around buds.
		April 20	Apparently in good condition.
		May 23	Only slight injury where bark was rough.
		Oct. 12	Tree alive and vigorous.
	Peach.....	April 11	Twigs somewhat injured.
		April 20	Tree nearly dead.
		June 20	Tree dead.
50	Apple.....	April 14	Slight injury to inner bark around buds.
		April 20	A few buds making an effort to start.
		May 23	All buds dead and inner bark injured. See Plate XXX.
		June 20	Tree dead.
	Peach.....	June 20	Tree dead and removed.
100	Apple.....	April 14	Slight injury to inner bark noticeable.
		April 20	Buds making a weak start.
		April 23	Inner bark killed around buds and in spots over tree.
		May 1	A few buds expanding. Bark all killed near ground.
		June 20	Tree dead.
	Peach.....	June 20	Tree dead and removed.

TABLE I — *Continued.*

SERIES II. 150° FLASH TEST ("WATER WHITE").

Oil applied Mar. 13. Partly overcast, no wind, temperature 35°–40° F.

Strength of oil.	Kind of tree.	Date of examination.	Effect on tree.
Per ct.			
15	Apple.....	April 11	No injury apparent.
		April 23	No injury apparent.
	Peach.....	April 11	Twigs show slight injury.
		April 20	Tips of nearly all branches dead.
		May 29	Tree killed back two-thirds.
25	Apple.....	April 11	No injury apparent.
		April 23	No injury apparent.
	Peach.....	April 20	Tips of nearly all branches dead. One-tenth of buds on body starting.
		May 29	Tree two-thirds dead.
50	Apple.....	April 11	Inner bark around buds apparently injured.
		April 14	Twigs show some injury.
		April 23	Buds all show injury.
		June 20	Tree nearly dead.
		Aug. 6	Tree dead and removed.
	Peach.....	April 20	Few buds starting at base of branches, tips all dead.
		April 23	Branches nearly all dead.
		May 29	Tree dead.
100	Apple.....	April 9	Inner bark around buds and scars discolored.
		April 14	Twigs show some external injury.
		April 23	Tree severely injured and taken out.
	Peach.....	May 29	Tree dead and removed.

TABLE II.— EFFECT OF KEROSENE ON SAN JOSE SCALE, 1900.

SERIES I. 100° FLASH TEST ("DISTILLATE").

Oil applied Jan. 22.

Strength of oil.	Kind of tree.	Date of examination.	Condition of scale insects.
Per ct. 15	Apple.....	April 9	Slightly infested when treated. No live insects.
25	Apple.....	April 11	Slightly infested when treated. A few live insects.
	Peach.....	April 11	Slightly infested when treated. No live insects.
50	Apple.....	....	Not infested.
	Peach.....	....	Not infested.
100	Apple.....	....	Not infested.
	Peach.....	....	Not infested.

SERIES II. 150° FLASH TEST ("WATER WHITE").

Oil applied Mar. 13.

Strength of oil.	Kind of tree.	Date of examination.	Condition of scale insects.
Per ct. 15	Apple.....	April 11	Only slightly infested when treated. No live specimens found.
	Peach.....	April 11	Slightly infested when treated. Live scales found.
25	Apple.....	April 11	Slightly infested when treated. No live scales.
	Peach.....	....	Not infested.
50	Apple.....	April 11	Slightly infested when treated. Four live scales.
		April 14	No live specimens found.
	Peach.....	April 20	No live scales found.
100	Apple.....	April 9	Slightly infested when treated. One live scale.
		April 14	No live specimens found.

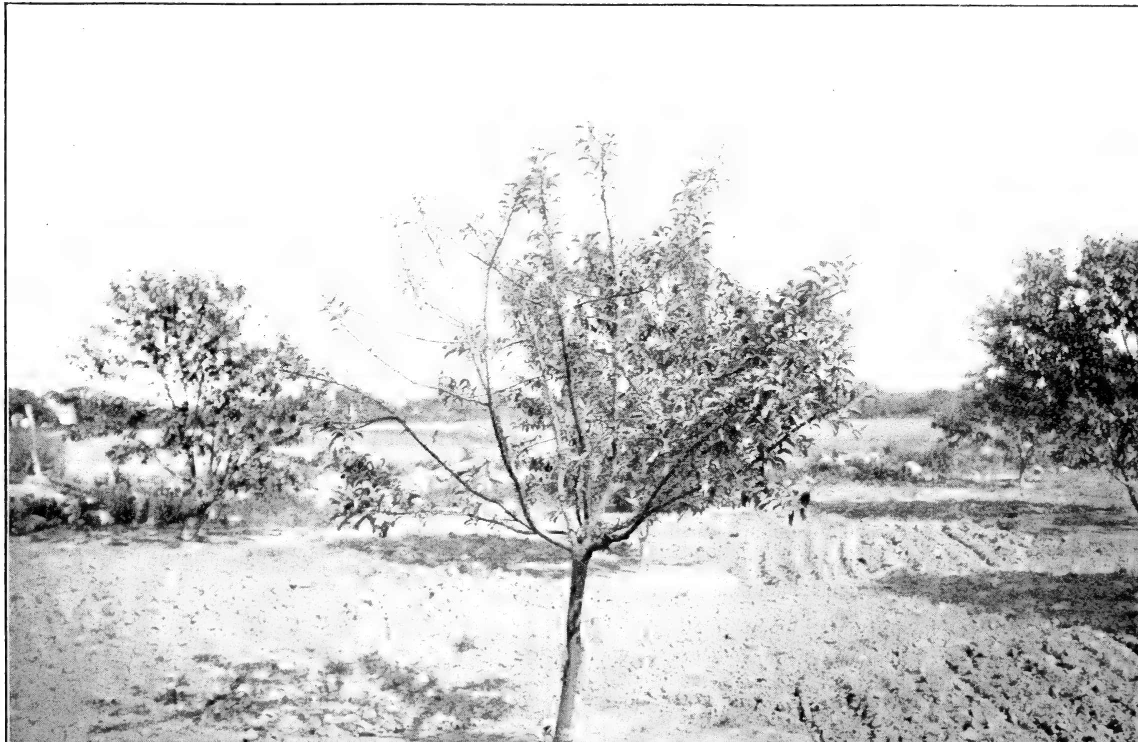

PLATE XXX.—APPLE, SPRAYED JAN. 22 WITH 100° FLASH TEST OIL, 50 PER CT. STRENGTH.
Photographed May 29, 1900.

PLATE XXXI.—TWO TREES IN LEFT FOREGROUND, 25 PER CT. CRUDE PETROLEUM; NEXT TWO, 50–60 PER CT. GAS OIL; TWO FOLLOWING, 50–60 PER CT. CRUDE PETROLEUM.

Photographed May 15, 1900.

Plate XXXII.—Hubbardston: At Left, Sprayed Winter and Spring; at Right, Winter only; Both with 15 per ct. Crude Petroleum.

Photographed May 17, 1901.

PLATE XXXIII.—PEACHES SPRAYED WITH 25 PER CT. CRUDE PETROLEUM: TWO AT LEFT, IN DECEMBER; NEXT TWO, BOTH DECEMBER AND APRIL; LIVE TREES AT RIGHT, IN APRIL ONLY.

Photographed June 18, 1901.

DIGEST OF RESULTS FROM USE OF KEROSENE.

Effect on trees.—A study of the notes on results indicates that it is unsafe to use low grade kerosene, 100° flash test ("distillate") in a mechanical mixture of 15 per ct. with water, on peach trees before there is a movement of the sap, that is, while trees are dormant; also that a 15 per ct. mixture of the same oil is liable to injure apple trees even though applied while the trees are dormant.

Powell[1] has shown that kerosene, 110° fire test, also known as "fuel oil" applied pure to pear in November, killed over 50 per ct. of the leaf and fruit buds. Lowe[2] found that a 15 per ct. mechanical mixture of 100° fire test kerosene, applied in summer, injured leaves of pear and apple. The combination of these results indicates that it is unsafe to use low grade kerosenes at any season of the year on any kind of tree.

In addition, the tests indicate that it is just as unsafe to use 150° flash test kerosene ("water white," ordinary illuminating oil), in a 15 per ct. mechanical mixture on dormant peach as it is to use a low grade oil, at least before there is any movement of the sap or swelling of the buds. Lowe[3] has shown that a 20 per ct. mechanical mixture of 150° "fire test oil" applied to peach while dormant killed trees. In Gould's[4] tests peaches were killed back one-third by an application of this grade of kerosene in a 20 per ct. mechanical mixture, while the trees were dormant.

Conversely a number of experimenters have found that 150° flash test kerosene can be applied to peach while in full leaf, in a 15 per ct. mechanical mixture, without injury.

The tests also indicate that it is unsafe to spray apple, in this section at least, as late as March 13 with either pure or a 50 per ct. mechanical mixture of the above grade of kerosene.

At Geneva, Lowe[5] only slightly injured apple by an application of pure kerosene applied as late as March 27.

In Maryland, Johnson[6] injured apple by the use of kerosene as early as March 3.

[1] 10th Rept. Del. Agr. Coll. Exp. Sta., 1898, p. 241.
[2] N. Y. Agr. Exp. Sta. Bul. 194, 1900.
[3] Idem.
[4] Md. Agr. Exp. Sta. Bul. 73, 1901.
[5] l. c.
[6] Md. Agr. Exp. Sta. Bul. 57. p. 101. 1898.

As stated at first, many of the tests in different sections of the country have not only been made under different conditions, on different kinds of trees, or if on same kinds of trees, at different periods and applied by different methods, also on trees of various sizes, age and condition of vigor. Hence, it is not an easy matter to draw comparisons. It is fair to conclude, though, that only the better grades of kerosene should be used, the difference in price not being sufficient to warrant the risk of using the cheaper grades. Even the best grade of kerosene is liable to injure trees unless applied at proper seasons by means of good apparatus in the hands of careful workmen.

The results, as a whole, indicate that mechanical mixtures ranging from 15 to 25 per ct. can be used on apple and pear while the trees are in full leaf with but slight injury to the trees; while the use of mechanical mixtures ranging from 10 to 15 per ct. under same conditions is liable to cause some injury to stone fruits. Such dilute mechanical mixtures, however, appear to be of value as insecticides only against the young insects before they have become fixed and cover themselves with a waxy scale.

Apparently a good grade of kerosene can be applied to large, vigorous pear and apple trees while they are perfectly dormant, and cause but slight injury to the trees, but in this locality March 1 is liable to be too late. After the sap commences to move there is more danger of injuring the trees. With stone fruits, especially peach, the reverse apparently holds good. That is, the use of even weak mechanical mixtures of kerosene on dormant peach is sure death to the tree, while during the period in early spring when the buds are swelling, but before opening, even pure kerosene can be applied with but slight injury.

No matter what strength nor what grade of kerosene is used, it will not kill the scale insects that are protected by rough bark and by buds, nor will it kill those it does not strike.

CRUDE PETROLEUM SERIES.

These tests were made, for the first series at Huntington, on Long Island; for the second series, at Yorktown, Westchester County. The charts given show the arrangement of the trees in the orchards and the number and the varieties of trees treated with each strength of petroleum.

CHART I.— TEST ORCHARD FOR CRUDE PETROLEUMS.

25 per ct. 0.79 sp. gr. (rows 1–24, first three columns) — Not treated. (last three columns, upper part)

c	c	h	h	h	h	k	k	k	k
h	c	c	c	c	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
c	c	c		h	b	b	k	k	k
c	h	s	c	h	b	b	k	k	k
c	c	c	h	c	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
s	c	c	c	h	h	b	k	k	k
c	c	c	c	h	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
c	h	h	s	c	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
c	c	c	c	h	b	b	k	k	k
s	c	c	c	c	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
c	c	c	s	c	b	b	k	k	k
c	c	c	s	s	b	b	k	k	k
c	c	c	c	c	b	b	k	k	k
s	c	c	c	c	b	b	k	k	k
c	c	c	c	s	b	b	k	k	k
c	c	c	c	c	b	b	b	k	k
c	c	c	c	c	b	b	b	k	k
c	c	c	c	c	b	b	b	k	k
c	s	c	c	c	b	b	b	k	k
c	c	c	c	c	b	b	b	k	k
c	c	c	c	c	b	b	b	k	k
c	c	c	c	c	b	b	b	k	k
c	c	c	c	c	b	s	b	k	k
c	c	c	c	c	b	b	b	k	k
c	c	c	c	c	b	b	b	k	k
c	c	c	c	c	b	b	b	k	k

15 per ct. 0.79 sp. gr. (columns 1–3, rows 25–37) — 60 per ct. 50 per ct. 0.83 sp. gr. (columns 4–5) — 60 per ct. 50 per ct. 0.79 sp. gr. (columns 6–8) — Not treated. (columns 9–10)

h Howell. s Sheldon. k Keiffer. b Bartlett. c Clapp's Favorite.

TABLE III.— EFFECT OF CRUDE PETROLEUM ON TREES.

SERIES I. SPECIFIC GRAVITY, 0.837 (35° BAUME OIL SCALE).

Applied Apr. 2 and 4, 1900. Clear, wind brisk, N. W. Trees 10 to 15 feet high. See Chart I.

Strength of oil.	Kind of tree.	Date of examination.	Effect on trees.
Per ct. 50–60	Pear	May 5	Trees have but few live buds.
		15	Trees show signs of developing latent buds.
		June 27	Two trees dead, six have some branches dead, remainder in same condition as those sprayed with 60 per ct. crude petroleum, sp. gr. 0.79.

Applied Mar. 13, 1900. Partly overcast, no wind, temperature 35° F.

Strength of oil.	Kind of tree.	Date of examination.	Effect on trees.
Per ct. 100	Apple	Apr. 12	Both buds and branches killed.
		23	Trees dead and removed.
	Peach	23	Tree dead and removed.

SERIES II. SPECIFIC GRAVITY 0.795 (43½° BAUME OIL SCALE).

Applied Apr. 16, 1900. Clear, wind light, N. W., temperature 80° F. in sun.

Strength of oil.	Kind of tree.	Date of examination.	Effect on trees.
Per ct. 15	Pear	May 5	Some flower buds injured.
		15	Trees in fairly good condition.
		June 27	Trees carrying considerable fruit.
25	Pear	May 5	Trees injured, especially on side next to spraying outfit.
		15	Some trees have not developed over one-half their buds.
		June 27	Trees carry a small amount of fruit. New leaves and numerous branches from latent buds give them the appearance of being very healthy and vigorous.

Chart II.— Plum and Peach Orchards of White & Rice, Yorktown, N. Y.

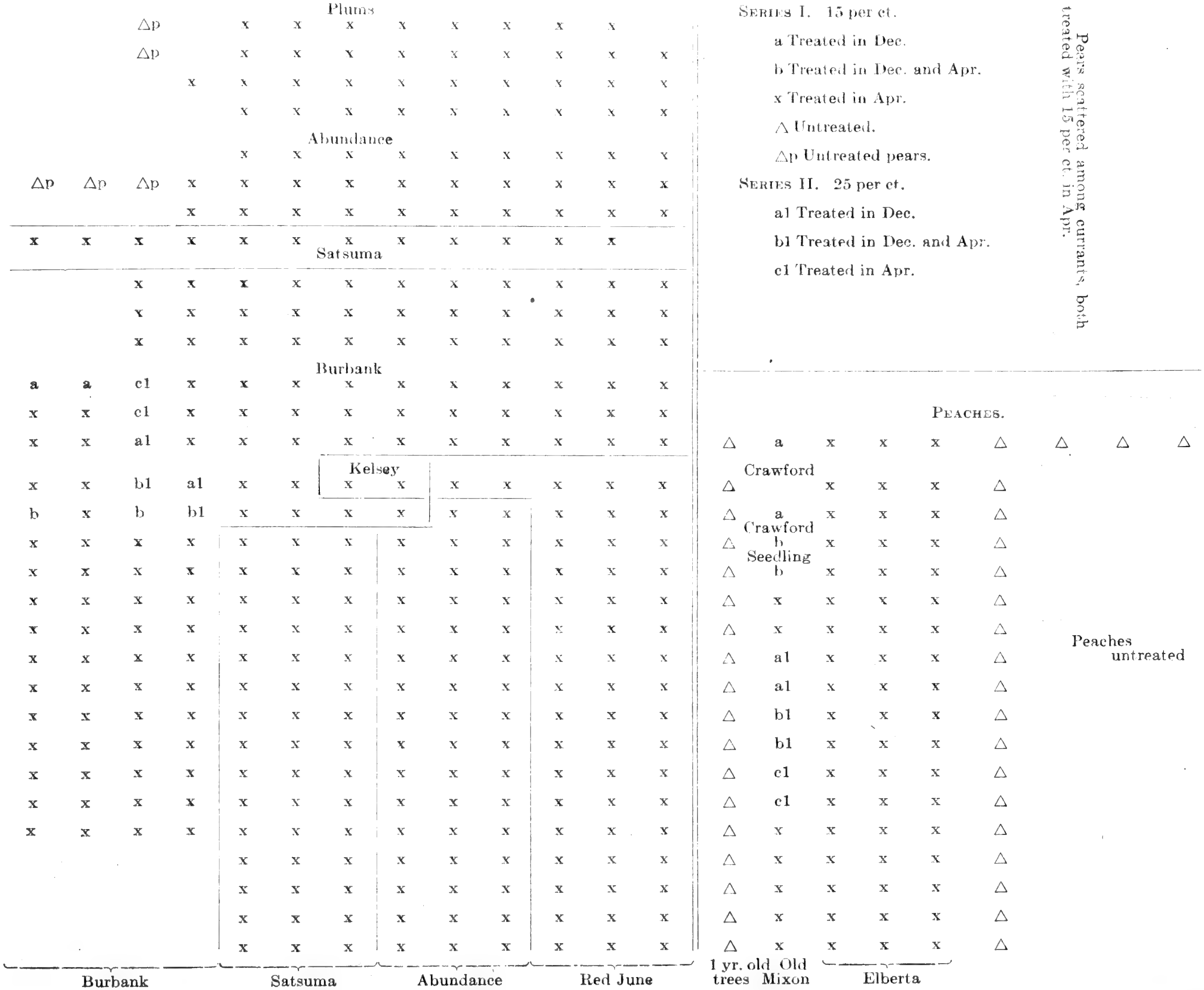

CHART III.—APPLE ORCHARD OF WHITE & RICE, YORKTOWN, N. Y.

SERIES I. 15 per ct.
(a) Treated in Dec.
(b) Treated in Dec. and Apr.
(c) Treated in Apr.
SERIES II. 25 per ct.
(a1) Treated in Dec.
(b1) Treated in Dec. and Apr.
(c1) Treated in Apr.
△ Untreated.

							x j
						x b	x n p
						x b	x
rus	x rus	x rus	x b	x b	x b	x rd	
x rus	x f	x f	x b	x b	x b	x b	x
△ h	△ h	△ h	△ b	△ b	x b	x s b	
△ g f	△ d o	△ crab	△ a s	x n s		x b	

Sprayed in Apr. with 15 per ct. oil

x pear

(c1)	(b1)	(a1)	(c)	(b)	(a)
△ b	△ b	△ b	△ b	△ g	△ g
x b	x b	x b	x b	x g	x g
x b	x b	x b	x b	x g	x g
x b	x b	x b	x b	x g	x g
x b	x b	x b	x h	x g	x g
x j	x j	x f	x f	x e j	x e j
x h	x h	x b	x h	x h	x d o
x h	x h	x h	x h	x h	x h
x r a	x r a	x r a	x r a	x r a	x r a
x r a	x f	x g	x pr	x p	x p
x j	x j		x seedling		x
SERIES II.			SERIES I.		

a s Autumn Strawberry
b Baldwin
d o Duchess of Oldenburg
e j Early Joe
f Fameuse
g Gravenstein

h Hubbardston
j Jonathan
n s Northern Spy
n p Newtown Pippin
p Park
pr Primate

r Russian
r a Red Astrachan
rus Russett
g f Gilliflower
s b Sweet Bough

Applied Apr. 2 and 4. Clear, wind brisk, N. W.

Strength of oil.	Kind of tree.	Date of examination.	Effect on trees.
Per ct. 50-60	Pear.....	May 5	Trees have but few living buds.
		15	Trees have about one-quarter normal set of leaves. Bark very thick and spongy.
		June 27	Trees have developed latent buds, branching profusely and appear very vigorous.

Applied Mar. 13. Cloudy, no wind, temperature 35° F.

Strength of oil.	Kind of tree.	Date of examination.	Effect on trees.
Per ct. 100	Apple....	Apr. 12	Slight injury to bark around buds.
		23	Some branches with buds all killed.
		May 29	Tree two-thirds killed.
	Peach.....	Apr. 12	Buds nearly all dead.
		23	A few buds making an effort to start.
		June 20	Tree dead.

TABLE IV.— EFFECT OF CRUDE PETROLEUM ON TREES.

SERIES I. SPECIFIC GRAVITY 0.79 (44° BAUME OIL SCALE).

Applied Apr. 12, 1901. Clear, wind brisk, S. W., trees 15 to 30 feet high.

Strength of oil.	Kind of tree.	Date of examination.	Effect on trees.
Per ct. 15	Pear.....	May 17	All trees show uneven application and considerable injury.

EFFECT OF CRUDE PETROLEUM ON SAN JOSE SCALE.

No living scale insects were found after treatment on the few slightly infested trees treated April 2 and 4 with crude petroleum of 0.79 and 0.83 specific gravity.

TESTS AT YORKTOWN.

During the winter of 1900-1901, two series of tests of crude petroleum were made at Yorktown, Westchester County, N. Y. The petroleum used had a specific gravity of 0.79 (44° on Baumé oil scale). Series I consisted of an application of 15 per ct. crude petroleum in a mechanical mixture with water as follows:

(a) One application in December.
(b) One application in December and one in April.
(c) One application in April.

Series II consisted of an application of 25 per ct. of crude petroleum in a mechanical mixture with water, under same conditions as Series I. In these tests the same spraying outfit was used as in previous tests.

Conditions.— The tests were made on plum, peach, pear and apple. The plum orchard was the center of infestation, to most parts of which the scale was uniformly distributed. It contained 360 trees between eight and fifteen feet high. The varieties, with arrangement and treatment, are shown on Chart II. The pear and peach orchards joined the plums on the east. The pear orchard was very irregular, part being old and part recently set trees; all were sprayed as a precaution against possible infection. The trees of the peach orchard which were slightly infested averaged about fifteen feet high. The arrangement and treatment of the latter is shown on Chart II. An apple orchard joined the plum orchard on the north; in this medium sized trees were twenty-five feet high. A few of the trees next the plum orchard were slightly infested. The varieties, their treatment and arrangement are shown on Chart III.

In all five barrels of crude petroleum were used in these tests. The average specific gravity of the five barrels was 0.79 (44° on Baumé oil scale).

The winter treatments were made on December 7, 22 and 24. Clear, bright days with as little wind as possible were selected. The spring applications were made on April 12 and 13, under nearly the same conditions as those of December.

TABLE V.— EFFECT OF CRUDE PETROLEUM ON TREES.

SERIES I. FIFTEEN PER CT. PETROLEUM; SPECIFIC GRAVITY 0.79.

NUMBER OF TREATMENTS.	Kind of tree.	Date of examination.	Condition of trees.
(*a*) One, December.	Apple....	Apr. 10	No trace of injury.
		May 16	Parks and Hubbardstons heavy set of flowers.
		Aug. 26	Hubbardstons show fine set of fruit.
	Peach	June 18	No branches killed. No set of fruit, otherwise healthy.
	Plum	Apr. 10	No injury apparent.
		June 18	Trees show rosettes of leaves as if affected with yellows.
(*b*) Two, Dec., Apr..	Apple....	May 2	Trees not starting as early as untreated trees.
		16	Parks show about three-fourths as much foliage and flowers as those of (*a*).
			Red Astrachans show only two-thirds as much foliage as those of (*a*).
			Hubbardstons show about one-tenth as much foliage and flowers as those of (*a*). See Plate XXXII.
		Aug. 26	No fruit on Hubbardstons.
	Peach	May 2	Not starting as early as untreated trees.
		May 16	Some branches show injury.
		June 18	One tree shows one-third crop of leaves. One tree one side killed.
	Plum	Apr. 10	No injury apparent.
		June 18	Trees show rosettes of leaves similar to yellows.
(*c*) One, April	Apple....	May 16	Northern Spy show some spurs without leaves and flowers. All trees show effect of uneven application.
		Aug. 26	Fameuse is the only variety showing no reduction in set of fruit.
	Peach	June 18	No trace of injury, fair set of fruit.
	Plum	June 18	No injury that can be laid to crude oil.

TABLE VI.— EFFECT OF CRUDE PETROLEUM ON TREES.

SERIES II. TWENTY-FIVE PER CT. PETROLEUM; SPECIFIC GRAVITY 0.79.

NUMBER OF TREATMENTS.	Kind of tree	Date of examination.		Condition of trees.
(*a*) One, December	Apple	Mar.	7	An occasional close-setting bud killed. Branches examined in laboratory.
		Apr.	10	No injury apparent. (Examined in orchard.)
		May	16	Red Astrachans, Jonathan and Hubbardstons show fine setting of flowers and leaves.
	Peach	Mar.	18	Trace of injury at union of one and two year old bark. (Examined in laboratory.)
		Apr.	10	Injury to bark also to buds and branchlets.
		May	2	All show injury.
			16	One tree dead.
		June	18	One tree with one live branch, other tree dead.
	Plum	Mar.	7	Some dead buds but possibly not from treatment. (Examined in laboratory.)
			18	No trace of injury to bark. (Examined in laboratory.)
		Apr.	10	A few buds killed, no injury to bark.
		June	18	One tree two-thirds dead. Weak from attacks of scale.
				All show rosettes of leaves and young branches from same twisted.
(*b*) Two, Dec., Apr.	Apple	May	2	Trees starting late.
			16	Red Astrachans show about one-fifth as much foliage and flowers as those of (*a*). Jonathans in same condition. Hubbardstons show one-tenth as much foliage and flowers as those of (*a*). All show effects of uneven application.
	Peach		2	Trees making a feeble effort to start.
		June	18	Trees dead. See Plate XXXIII.
	Plum	May	2	Bark injured in spots.
		June	18	Many spurs without fruit of leaves. Trees all show rosettes.
(*c*) One, April......	Apple	May	16	Trees all show effect of uneven application.[1]
		Aug.	26	The set of fruit is light on all trees of this subseries.
	Peach	May	26	No trace of injury.
		June	18	No trace of injury, light crop of fruit.
	Plum	June	18	Leaves of some trees off color.
		Aug.	26	"Off colored" leaves have disappeared.

[1]In some cases the trees show that all parts were not reached, while apparently in other cases it was impossible to throw the spray onto the inner branches against the wind.

TABLE VII.— EFFECT OF CRUDE PETROLEUM ON SAN JOSE SCALE.

Conditions prior to treatment, April 10, 1901. (Examinations made in field with hand lens.)

	Living.	Dead.	Living.
			Per ct.
(*a*) Plum slightly infested	5	18	21.74
" badly infested	20	110	15.38
(*b*) Peach moderately infested	7	173	3.88
Average	10.6	100.3	

Table VII — *Continued.*

SERIES I. FIFTEEN PER CT. PETROLEUM; SPECIFIC GRAVITY 0.79.

Number of treatments.	Kind of tree.	Date of examination.	Condition of scales.
(*a*) One, December.	Apple....	Apr. 10	Living specimens found near ends of branches on all trees infested at time of treatment.
		Aug. 26	Jonathans show living scales on fruit.
	Peach....	Mar. 18	On twigs from slightly infested tree, no living specimens found.
		June 18	Living scales found on body of one tree.
	Plum	Apr. 10	Living scales found.
		June 18	On trees badly infested at time of treatment, living scales were found near tips of branches.
(*b*) Two, Dec., Apr.	Apple....	June 18	Living scales found near tips of twigs.
		Aug. 26	Living scales found near tips of twigs.
	Peach....	June 18	No living scales found. Slightly infested at time of treatment.
	Plum	June 18	No living scales found. Slightly infested at time of treatment.
		Aug. 26	Living scales found on one tree.
(*c*) One, April.....	Apple....	Aug. 26	Living scales found on all infested trees.
	Peach....	June 18	All trees infested prior to treatment, show living scales in exposed places.
		Aug. 26	All trees infested prior to treatment, show living scales in exposed places.
	Plum	June 18	All trees infested at time of treatment, show living scales. In one case live specimens found on body of tree where there was still traces of oil.
		Aug. 26	A few trees show scales on fruit, but not abundant enough to disfigure.

TABLE VIII.— EFFECT OF CRUDE PETROLEUM ON SAN JOSE SCALE.

SERIES II. TWENTY-FIVE PER CT. PETROLEUM; SPECIFIC GRAVITY 0.79.

Number of treatments.	Kind of tree.	Date of examination.	Condition of scales.
(*a*) One, December.	Apple....	Apr. 10	A few living specimens found on infested trees.
		Aug. 2	Jonathans show living scales on fruit.
	Peach....	Mar. 18	No living scales on twigs sent for examination.
	Plum	Mar. 7	Living scales on twigs sent for examination.
		June 18	Living scales found in exposed places. Trees moderately infested at time of treatment.
(*b*) Two, Dec., Apr.	Apple....	June 19	Living scales found on Jonathan.
		Nov.	Living scale found on fruit of Jonathan.
	Peach....		(Trees killed.)
	Plum	June 18	Living scales found on one tree slightly infested at time of treatment.
(*c*) One, April	Apple....	Nov.	A few living scales found on fruit of Baldwins and Jonathans.
	Peach....	June 18	Living scales found on body of trees in exposed places.[1]
	Plum	June 18	Living scales found on trees in exposed places.
		Aug. 26	Trees still show a few living scales.

DIGEST OF RESULTS FROM USE OF CRUDE PETROLEUM.

Effect on trees.—The tests made in the spring of 1900 show, first, that pure crude petroleum and even a 50 per ct. mechanical mixture of a grade known as "Gas oil" or "Reduced oil" (specific gravity 0.837) cannot be safely used on either apple, peach or pear. Second, that crude petroleum, specific gravity 0.795 or heavier, cannot be used even in a mechanical mixture of 15 per ct. on pear after the buds are swollen, without some injury to the set of fruit, and where used in a mechanical mixture of 50 and 60 per ct., all the fruit buds reached were killed,

[1]Many of the living specimens found on peach and plum were in exposed places on body and larger branches. In most cases they were on the underside of a branch where it joined the body, or in spots which showed slight or no traces of crude petroleum. In one instance where the 15 per cent mechanical mixture was used, they were found on the smooth bark of plum, where they should have been reached, and everything indicated that they had been reached with the spray.

In the case of apples the living specimens were generally found under buds. Their occurrence on fruit of apple, also on plum, indicates that they were not reached at tips of branches, under buds and bud clusters.

and in addition this application caused the bark to become spongy.

Spongy bark does not always occur. From observations in other orchards where crude petroleum was used, the indications are that sunlight and heat acting on the coating of vaseline, have something to do with producing this condition.

It is fair to state that most of the above pear trees recovered from the treatment. By the latter part of June they are covered with new foliage, and as Dr. Smith[7] says "The oil seems to have acted as a stimulant, the sprayed trees have shown greater vigor and better foliage than those untreated." The latter condition apparently resulted from the development of latent buds, which formed numerous small, undesirable branches. It is a question whether these branches were not of the same nature as what are called "water-shoots" indicating weakness of trees.

Tests made in the winter of 1900-1901 show: First, that the use of a 15 per ct. mechanical mixture of crude peroleum, specific gravity 0.79, on peaches in December destroyed all fruit buds, and a 25 per ct. mechanical mixture killed the trees outright. Badly infested plums treated at the same time and in same manner with same grade of crude petroleum were somewhat injured; while apple trees treated on same dates with same amounts and grade of crude petroleum were not injured in the least.

Second, that neither a 15 nor a 25 per ct. mechanical mixture of crude petroleum, specific gravity 0.79, applied to peach and plum in April, or after the buds commence to swell, produced any injury; while the same amounts and grade of crude petroleum applied to apple and pear on same dates, slightly injured apple and destroyed nearly all fruit buds on pear.

Third, that two applications of crude petroleum, specific gravity 0.79 in either 15 or 25 per ct. mechanical mixtures, during the same winter are fatal to peach, very injurious to apple and slightly injurious to plums (Japanese varieties). Possibly in this case, the principal injury to the peach may have resulted from the December treatment, and conversely the major portion of the injury to the apple trees may have resulted from the April treatment.

[7] N. J. Agr. Exp. Sta. Bul. 138, p. 20.

Results obtained by Felt[8] show that pears treated with 20 and 25 per ct. mechanical mixtures of crude petroleum applied in April were injured.

Sanderson[9] reports no injury to pears sprayed March 21 with a 25 per ct. mechanical mixture of crude petroleum.

From observations made in orchards in the Hudson Valley, Slingerland[10] concludes that there is less danger of injury to apple trees, from a 25 per ct. mechanical mixture of crude petroleum, if sprayed in April instead of earlier in the winter.

Webster[11] reports injury to three-year-old apple trees, by an application of pure crude petroleum, sp. gr. 0.83, applied in March. His illustrations show that one tree had all leaf and fruit buds, reached by the crude petroleum, killed; after which the trees developed latent buds.

Johnson[12] says: "Apple and pear can be treated with crude oil pure or in a mechanical mixture, any time during winter. The same material can be used on plum and peach in a 20 to 25 per ct. mixture, but the application should not be made before March or April."

Smith[13] has shown that pure crude petroleum can be applied to peach in early spring without injury. It should be explained that his results were obtained on small trees that could either be painted by hand or sprayed with a small hand atomizer, hence do not furnish a fair basis for comparison with orchard work in general.

Many more instances might be added, showing how variable the results obtained can be. These have been obtained under just as variable conditions as those from the use of kerosene, hence are just as difficult to compare.

In general, all the results obtained through Experiment Station tests, together with those obtained by orchardists, show that peach and plum can be quite safely sprayed with 25 per ct. mechanical mixtures of crude petroleum having a specific grav-

[8]16th Rept. State Ent. on Injurious and other Insects, 1901.

[9]12th Ann. Rept. Del. Coll. Agr. Exp. Sta., 1900.

[10]*Rural New-Yorker*, Nov. 3, 1900.

[11]Ohio Hort. Rept., 1900.

[12]*Amer. Agrl.*, Dec. 29, 1900.

[13]N. J. Agr. Coll. Exp. Sta. Rept. for 1889 and 1900.

ity of 0.79 ($43\frac{1}{2}°$ to 44° on Baumé oil scale) providing the applications are made after the buds commence to swell. While if treated when dormant the trees are generally injured and in many cases killed outright.

As a whole, the results of tests on apple and pear are still more confusing. Our tests show plainly that pears can not be treated after buds have commenced to swell; they also indicate that the same is true of apples. The majority of results indicate that apple can be treated while perfectly dormant with little danger of injury even with 50 per ct. mechanical mixtures of crude petroleum.[14]

Effect on scale.— The results indicate first, that one application of a 15 per ct. mechanical mixture of crude petroleum, specific gravity 0.79, did not kill all the scale insects, even though they were situated in exposed places.

Second, that double applications of the above percentage of crude petroleum killed all that were reached as did also all the 25 per ct. mechanical mixtures whether double or single applications.

In addition the results show, that it is a mechanical impossibility to reach those individual scale insects protected by buds or rosettes of buds with crude petroleum, without drenching the buds to such an extent as to injure the latter.

COST OF SPRAYING.

Smith has stated that the cost of spraying with kerosene or with crude petroleum need not exceed one or two cents per tree, meaning of course very small trees.

It cost us seven cents per tree for crude petroleum to spray pear trees averaging 12 feet high, and 5 cents per tree for labor, making a total of 12 cents per tree.

The cost of crude petroleum for spraying standard apple trees averaging 25 feet high, was 30 cents per tree, estimated cost of labor per tree, 10 cents, making a total of 40 cents per tree.

As set forth by Dr. Smith there is no insecticidal value in the water used. The latter simply acts as a carrier, helps to avoid drenching and at the same time lessens the expense. On small trees and shrubbery which can be painted by hand or sprayed with an atomizer, water is a detriment.

From this it will be seen that the subject of cost of spraying is just as variable as that of fumigation. That it depends on cost of materials, the distance they have to be freighted, the size of the trees, etc.

It has been shown under cost of fumigation that the expense of fumigating the largest trees that could be covered by box fumigators need not exceed 34 cents. The cost of spraying the same size of trees with crude petroleum need not exceed 12 cents per tree. Which shows that spraying costs about one-third as much as fumigation. Spraying has the disadvantage of being an uncertain method of treatment, not only uncertain as to effect upon the scale insect, but also upon the trees. In fact the margin between the amount of oil required to injure the pernicious scale and to injure the tree upon which the insect occurs is so close that it is a lottery as to what the result will be. Furthermore, oil spraying at best is disagreeable and an undesirable method of controlling the pest.

SAN JOSE SCALE INVESTIGATIONS. IV.*

V. H. Lowe and P. J. Parrott.

SUMMARY.

Experiments with the lime-sulphur-salt wash conducted in orchards located on Long Island, in the Upper Hudson Valley, and in Ontario and Niagara counties gave uniform results indicating that this wash is a safe and reliable remedy for the San José scale in the East.

Experiments with the wash sprayed upon infested apples in the laboratory showed that it kills the insects in two ways: First, directly through its soluble compounds and probably very soon after coming in contact with them, thus acting as a contact poison; and, second, indirectly through its insoluble or slowly soluble compounds which form a crust preventing the development of the young scales.

Summer treatment with lime-sulphur washes resulted in killing the scales without injuring the trees (Japan plum trees) with the sulphur in the proportion of one pound to ten pounds of lime.

Experiments in making a lime-sulphur wash by using caustic soda or potash, to avoid the necessity of boiling, gave promising results. This wash is intended to take the place of the standard lime-sulphur-salt wash. Further experiments are necessary to determine its value.

Experiments were made with various other washes including resin washes, lime-water and kerosene wash, lime-sulphur-salt wash and casein, and potash-sulphur wash, with the result that none of the compounds tested gave better results than the lime-sulphur-salt wash.

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*A reprint of Bulletin No. 228.

I. SPRAYING EXPERIMENTS WITH THE LIME-SULPHUR-SALT WASH.

HISTORY AND PRESENT STATUS OF THE WASH IN THE EAST.

The origin of the lime-sulphur-salt wash seems to be in doubt. A wash containing these ingredients is said to have been used in California as a sheep dip long before a use was found for it in the orchard. When a need for a safe remedy for scale insects was felt on the Pacific Coast it was one of the first washes to be tested. It was considered satisfactory and is now said to be the principal wash used as a remedy for the San José scale in California.

The wash was first tested in the East by Marlatt and Coquillett[1] in 1895 with such unfavorable results that no further attempts were made to use it in eastern orchards until Marlatt[2] again tested it at Washington in 1900 with much better success. The explanation given is that about three weeks of unusually dry weather immediately following the treatment prevented the washing off of the compound before the scales had been killed; and it was suggested that if the treatment was followed by two or three weeks of comparatively dry weather it would probably prove a satisfactory remedy. More recent results are those obtained by Smith of New Jersey, Forbes of Illinois and Scott of Georgia, all of which are, in the main, favorable to the lime-sulphur-salt wash, and have resulted in showing that its adhesive qualities are better than was at first supposed.

While the more recent experiments are promising they have not yet been sufficiently extensive to determine the real status of the wash as a remedy for the scale under eastern conditions. There is need, therefore, for further experiment on as large a scale as is consistent with thorough work.

LOCATION, PLAN AND OBJECTS OF THE EXPERIMENTS.

The orchards in which these experiments were conducted are situated on Long Island near Riverhead, in the upper Hudson Valley near Kinderhook, Columbia County, and in western New

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[1] U. S. Dept. Agr. Div. Ent. Bul. 3, N. S., pp. 56–71.
[2] U. S. Dept. Agr. Div. Ent. Bul. 30, N. S., pp. 34–37.

York at Geneva and near Youngstown in Niagara County. The experiments were distributed well over the State with the hope that the treated trees would be subjected to a variety of weather conditions which, taken together, would give the wash a severe test and also furnish data showing, as far as possible in one series of experiments, the effects of the treatment under different weather conditions. The extent to which this plan proved successful is shown on subsequent pages.

In making the selections much pains was taken to secure trees that were well infested with the scale but not seriously injured by other insects or diseases. But as extensive infestation and lack of care are very apt to go together it was, as a rule, difficult to find badly infested trees that were not weakened by lack of proper cultivation as well as by the scale. In order that the conditions under which each experiment was made may be understood, a brief history of each orchard is given together with a description of the condition of the trees at the time of treatment.

METHOD OF DETERMINING RESULTS.

As a basis for the determination of results, check trees were selected from the orchards in which the experiments were made, much pains being taken to include only those which, in point of infestation and vigor, would average about the same as the treated trees. No attempt was made to count the scales on the trees, either before or after treatment, as it was considered practically impossible to count enough of them to furnish adequate data upon which to base results. This method was found very satisfactory, however, for laboratory experiments with infested apples. In all of these experiments the results were based upon careful comparisons, made as frequently as circumstances would permit, between the treated and check trees, especial pains being taken to ascertain the condition of the trees toward the close of the season both as to the character of the foliage and fruit and the degree of infestation.

No attempt was made to conduct the experiments upon a commercial scale for it is considered that in this case, as with any insecticide, the point first to be determined is the degree of its

efficiency when applied as thoroughly as possible. Otherwise but little definite data can be secured. If it is shown to be efficient when thoroughly applied, the success or failure attending its use on a commercial scale will depend upon the ease of application and the quality of the work done. For this reason comparatively few trees were used, the total number for the early spring treatment amounting to but 710.

PREPARATION AND APPLICATION OF THE WASH.

Several preliminary tests were made with different formulae, but the one finally decided upon as giving the best results in the preliminary tests is as follows:

[3]Lime, unslaked	40 pounds.
Sulphur, ground	20 pounds.
Salt	15 pounds.
Water	60 gallons.

The lime was slaked in a large iron kettle to form a creamy solution. As soon as the action of the lime had ceased, the sulphur and salt, together with about 30 gallons of water, were added and the whole boiled for at least two hours. It was then diluted to 60 gallons with boiling water or with cold water and the whole brought to the boiling point. To prevent clogging the machinery the mixture should be strained through a fine wire net as it is being poured into the tank. The tendency of the sulphur to form lumps in the mixture can be avoided by making a thin paste of the sulphur with a little water and stirring it in slowly.

The mixture may be boiled either in large iron kettles over a fire, or in barrels with live steam, or in tanks made for the purpose. For small orchards the former will answer very well. The kettles should hold at least 60 to 80 gallons each and should be so arranged as to be conveniently heated over a wood fire, as shown in Plate XXXIV, or by means of a stove into which

[3]The formula given in Bulletin 212 of this Station, p. 211, gives 30 instead of 40 pounds of lime. In either case there is an excess and undoubtedly within quite broad limits the quantity makes no important difference in the immediate effects of the wash upon the scale. A liberal amount of lime, however, causes the mixture to adhere better and also probably delays the weathering away of the soluble ingredients.

the kettle is built. It will be found to be an advantage to have two kettles in use so that while one is being emptied the other kettle full of mixture can be in preparation.

Where practicable the steam boiling method is to be preferred as there are no open fires to be watched and the boiling is apt to be more thorough. If the orchard to be sprayed is not too large, enough of the mixture can be boiled in three or four barrels to keep the machines supplied. For large orchards, one large, or, preferably, two smaller vats may be built, into which the steam is carried from a nearby boiler. For an orchard of 100 acres two vats measuring about 5 feet long, 3 feet wide and 30 inches deep will be found large enough to supply the mixture needed. Each of these tanks will hold approximately 280 gallons. It will be found convenient to have them about four feet above the ground with a platform between about four feet wide, upon which a man may stand to attend the spray while boiling. A faucet for drawing off the mixture into the spraying machine should be provided at the end of each vat. It will also be found an advantage to have the floor slope slightly toward the faucet.[4]

The machinery required for applying the lime-sulphur-salt wash does not differ from that required for effectual work with bordeaux mixture. As for spraying bordeaux mixture, however, it is of especial importance that the pump give a uniform high pressure to insure an effectual spray. In these experiments ordinary bordeaux spraying machines were used. Various nozzles were tested with a view to ascertaining the makes best adapted to the wash. The list includes the following: Cyclone, Cyclone with direct disgorger, Seneca, Bordeaux, Vermorel, McGowan, San José, Graduate and Nixon. The Seneca and Vermorel proved to be the most satisfactory.

The method of spraying the trees was practically the same in all of the orchards. To insure thoroughness the trees were carefully sprayed once and as soon as the mixture was dry they were

[4]For detailed descriptions of steam boiling plants for supplying the lime-sulphur-salt wash for spraying orchards of from 20 to 1,000 acres the reader is referred to Bul. No. 20 of the Division of Vegetable Pathology of the U. S. Dept. Agr., by Newton B. Pierce. The plants therein described are in use in California.

closely examined once and usually a second time, the spray being applied each time to those parts of the trees that had escaped thorough treatment.

CHARACTER OF THE LIME-SULPHUR-SALT WASH.

When thoroughly cooked the lime-sulphur-salt wash is a heavy, very caustic, brownish or yellowish-green liquid having a sulphurous odor. When allowed to stand, the heavy ingredients quickly settle, leaving the clear, orange-red liquid. Long, brownish crystals soon form in the precipitate. If carefully made and thoroughly strained, it sprays about the same as standard bordeaux mixture.

The following analysis, by Mr. F. D. Fuller of the Station staff, of a thoroughly cooked sample indicates the chemical nature of the wash:

"In the examination of the lime, sulphur and salt wash, special attention was directed toward a study of the combination between the lime and sulphur, as it was thought that no chemical reaction took place between the lime and salt, but rather that the salt was added to raise the boiling point of the mixture and possibly effect a more complete combination between the lime and sulphur.

"In the preparation of this wash, the three ingredients are boiled together for some time, which causes the sulphur to enter into solution combined with the lime in various proportions. The orange-red solution which is formed contains the following lime compounds: calcium sulphide (CaS), some of the polysulphides of calcium (CaS_3 and CaS_5), calcium sulphate ($CaSO_4$), a large quantity of calcium thiosulphate ($CaS_2 O_3$) and some calcium sulphite ($CaSO_3$). There is quite an excess of lime present which settles out on standing.

"The insecticidal value of this wash is probably due to the various sulphur compounds present as sulphides, sulphites, sulphates and thiosulphates, and it is immaterial whether all the sulphur is combined thus with calcium or whether some is united to sodium. There is no direct evidence that the salt and lime react chemically, and it is safe to conclude that the most

important function of the salt is to affect the physical characteristics of the mixture, as noted above. In fact, I am led to believe that an equally effectual wash can be prepared by omitting the salt and prolonged boiling and using an alkali instead.

" In applying this mixture during a wet season the soluble compounds like the sulphides and thiosulphates would be washed out and the sulphites and sulphates, being slightly soluble in water, would disappear to some extent, leaving lime ($Ca(OH)_2$), which would gradually absorb carbon dioxide (CO_2) from the air forming the insoluble calcium carbonate ($CaCO_3$).

"Applied during a drought, gradual decomposition would take place. The thiosulphates would break up, liberating sulphur (S) and the sulphites and sulphides would probably oxidize to the sulphates. The lime would eventually change to the carbonate, giving the trees a coating of white."

1. EARLY SPRING TREATMENT WITH THE LIME-SULPHUR-SALT WASH.

For the experiments in this series the winter wash was used. It was made after the formula given on page 284. The treatment and results in the five orchards included in this series are as follows:

ORCHARD I, LONG ISLAND, PEACHES AND JAPANESE PLUMS.

This orchard is located about three miles northeast of Riverhead. It consists of 242 trees, of which 152 are peaches and the remainder plums. The peaches include nine varieties, as follows: Iron Mountain, 29; Wheatland, 27; Crosby, 6; Waterloo, 17; Alexander, 18; Champion, 12; Early Crawford, 6; Late Crawford, 18, and Elberta, 11. The plums, 42 in all, are Japanese varieties, principally Burbank.

The peaches have been set about eight years and the plums five. The orchard has had fair cultivation until the past two years, when it has been neglected and allowed to run down. The peaches especially showed poor growth and most of them were much weakened by the scale. The plums were in much better condition. When the trees first became infested is not

definitely known, but at the time the spraying was done nearly one-third of the peaches were encrusted on the trunks and larger branches, and the remainder to a somewhat less degree. The plums were less seriously infested. The orchard, therefore, afforded an excellent opportunity to test the wash upon weak trees as well as upon the scale.

Checks.— The checks consisted of eight trees selected as being representative of the various degrees of infestation and health of the trees throughout the orchard. An adjoining orchard of over a hundred trees of the same varieties, which was infested to about the same degree also furnished material for comparison.

Conditions.— The trees were sprayed March 25 to 29. The weather was cloudy with a heavy wind most of the time. The temperature varied from 32° to 56° with heavy frosts at night. As a result of the frosts the trees were wet when the spraying began in the morning and did not usually dry until about the middle of the forenoon.

The trees were sprayed thoroughly once and as soon as the wash was dry were carefully examined and the branches that were not well coated were sprayed again. This was followed by a second examination and treatment after sufficient time had elapsed for the second coat to dry. After the spraying was finished the trees were trimmed and any branches that were not thoroughly sprayed were cut out. The amount of mixture used averaged nearly one and one-third gallons per tree.

The weather conditions during the three weeks immediately following the treatment of the trees were as follows: There was a light rain March 28 followed by heavy showers and high wind the following day, which lasted from about five in the morning until nearly noon. Although the weather was usually cloudy there was little rain until April 26. On this date and also on April 29 and 30 there were continued heavy rains and wind. Taken as a whole, the season has been a fairly wet one on the eastern half of Long Island, and hence in this orchard the adhesive qualities of the wash have been given about an average test.

Results on peaches.— The trees were carefully watched and frequent examinations made during the spring and summer. The final examinations were made August 2. Early in the season there appeared to be evidence of injury. The buds of the treated trees were about a week later in opening than those of the untreated trees. When once well started, however, there was no further delay and the treated trees were soon as full of blossoms and the foliage as abundant as on the check trees. By the time the final examinations were made the treated trees were in much better conditions than the checks. There was not the slightest evidence of injury. The rapid multiplication of the scales had resulted in added injury to the untreated trees, especially those that were most extensively infested early in the season, while the checking of the insects by the treatment had permitted the sprayed trees to recuperate to some extent.

Results on plums.— Except for very slight injury to the fruit buds, the effect upon the plums was practically the same as upon the peaches. The buds were delayed in opening about the same length of time. Although there was very little fruit upon any of the plum trees, it was uniformly somewhat more scarce upon the treated trees than upon the untreated trees, thus indicating slight injury to the fruit buds.

Effects on the scale.— The effect upon the scale was evidently of a two-fold nature, an immediate and a secondary effect. The immediate effect is the death of all or nearly all of the scales with which the mixture comes in contact within a few days after the application is made. This was shown not only by the fact that but very few live scales could be found within a week after the treatment was made but also from the fact that later examinations showed the scales to have been killed while still in the hibernating stage. As the treatment was made only a short time before the scales would normally have begun to enlarge the effect must have been fairly prompt.

The secondary effect appears to have been a purely mechanical one caused by the abundance of residue adhering to the trees, which prevented the newly hatched young from finding

a suitable place to settle down. Thus on the treated trees a few of the adults always escaped but a large percentage of the young were evidently unable to survive. This was indicated by the fact that during the summer live scales were found in protected places and although they produced young but little evidence could be found that the young had survived. The final examination showed only an occasional live scale and these were invariably upon the new growth, showing that the young that survived were those that had succeeded in reaching the new growth.

Comparing the treated with the untreated trees, the scales on the latter had multiplied rapidly during the summer, causing these trees to look sickly and in some instances nearly resulting in their death. The treated trees had recuperated somewhat from the previous injurious effects of the scale and had made a very good growth. The foliage also was fairly abundant and the crop of salable fruit in excess of that on the untreated trees.

Effect of the weather upon the wash.—As shown on page 398 there was but one heavy rain during the first four weeks after the trees were sprayed, and that was immediately after the work was completed. It evidently had but little effect. There was also no evidence of the washing off of the mixture until during May, when it began to disappear slowly as a result of frequent rains. A dirty gray residue remained upon the peach trees throughout the season. It showed very plainly August 2. The smooth bark of the plums, however, did not retain a residue as readily and nearly all the trees had been washed clean by the time the final examination was made, although they remained white for nearly three months after being sprayed. The only evidence that the wash had been applied was on the trunks and in protected places on the larger limbs where a thin coating was still adhering.

ORCHARD II, COLUMBIA COUNTY, PLUMS AND PEACHES.

This orchard consists of a small block of trees situated about two miles southeast of Kinderhook. Forty-seven trees were selected for treatment, including 36 plums and 11 peaches. The

plums consisted of the following varieties and were infested as follows: 26 Burbank, 4 encrusted and the remainder moderately infested; 6 Abundance, slightly infested; 1 each of Satsuma and Hale, slightly infested; 2 Red June, slightly infested. The peaches included two varieties as follows: 6 Stevens Rareripe, 3 encrusted on about one-third of the tree and the remainder very slightly or not at all infested; 5 Chair Choice, 2 encrusted on about one-third of the tree and the remainder slightly infested.

The trees were not all of the same age, parts of the orchard having been recently replanted, but those treated varied from eight to twelve years of age. They have been under careful cultivation from the first and except for the scale are in good condition.

Checks.— Check trees of about the same condition and degrees of infestation were chosen from a nearby orchard. The total number of checks amounted to about one-fourth the number treated.

Conditions.— The trees were sprayed March 31 and April 1. The buds were well swollen, but none of them had burst. The work of spraying was not begun until late in the afternoon of the first day and at about the time that a cold, drizzling rain began. Before the afternoon was over the rain was followed by snow and a drop in the temperature that caused ice to form on the trees. Before night the wet snow was clinging to the branches in many places to a depth of half an inch. One row was sprayed while the rain was falling and another after the snow and ice had formed on the branches. In some places the spray melted the snow and thereby added moisture to the branches until they were dripping wet. Where the ice had formed a thick coating, however, the mixture did not dissolve it but stained it a green color and finally reduced it to a greenish, granular mass. To all appearances, if the mixture was not soon washed off by the melting snow and ice it would be frozen in the snow and ice and at the first thaw would be carried off. This did not prove to be the case, however, for by ten o'clock the following morning the snow and ice had melted and before noon the mixture was sufficiently conspicuous to give the trees

the appearance of having been well whitewashed. About noon of the second day the weather turned colder and remained so for several days. During the two days that the trees were being sprayed the temperature varied from 30° to 40°. The weather was, as a rule, cloudy, with light wind the first day and heavy wind the second.

The spray was applied in this orchard as described for Orchard I, each tree being thoroughly sprayed once and carefully retouched twice. The trees were not trimmed, however, after the spray had been applied. Owing to a leaky pump and poor nozzles the amount of mixture averaged nearly three gallons per tree in this orchard. McGowan nozzles were used. The mixture was made in a large iron kettle holding about 60 gallons, which was heated by an open fire.

During the thirty days immediately following the treatment the weather was usually cloudy, there being but seven days of fair weather. From April 3 to May 4 there was rain or snow on nine days, as follows: April 3, snow squalls; 6, light rain at night; 8, light rain afternoon and night with high wind followed by heavy rain and wind, lasting most of the following day; 10, light rain most of the day; 11 and 12, light showers; 26, heavy showers in the morning followed by light rains the remainder of the day; 29, moderately heavy rain at night followed by heavy showers the following night; May 3, light rain followed by heavy showers the following day.

Results on plums.— The same general effect was noticed here as on Long Island. On the average the buds were about a week late in opening, but otherwise there was no apparent effect on the trees. Especial pains was taken to discover any injury to the fruit buds, but there was no evidence that they were injured in the slightest. The trees bore fully as much fruit and in some cases more than the uninfested trees.

Results on peaches.— The effect on the peaches was practically the same as on the plums.

Effect on the scale. — The comparatively few trees in this orchard that were encrusted with the scale did not give as good opportunity for observing the effects on the scale as in some of

the other orchards. The trees were carefully examined during the season, however, but only on two trees were live scales found, and these were very few in number. All the other trees seemed to be free from the insects, although this could not be determined positively in one season. The fruit showed no evidence of the scale.

Effect of the weather upon the wash.— It will be observed that, owing to the severe rains during the thirty days immediately following the spraying of this orchard, the wash was subjected to a severe test, but that in spite of this fact the killing effects were apparently not diminished. In this orchard the mixture was washed off from the plums somewhat more readily than from the peaches, but all of the trees remained white for more than two months. On July 30 when the final examination was made there was sufficient residue adhering to the bark of all of the trees to give them a dull gray appearance, especially upon the trunks and larger limbs.

ORCHARD III, COLUMBIA COUNTY, PEARS.

This orchard is situated in the village of Kinderhook. It consists of 82 pear trees, 35 of which were encrusted with the scale and much weakend by it. The remainder were badly infested but not encrusted. The varieties include Bartlett, Keiffer and Burre Bosc. The Bartlett and Burre Bosc had the most scale, the Keiffers being only slightly infested. The trees have been planted about eight years, but owing to neglect have made a very poor growth, and many of them were much weakened by the scale. During the past two years, however, the orchard has received more attention, with the result that, except for the scale, the trees were beginning to show signs of improvement. A short time before the spray was applied the trees were well trimmed.

Checks.— The checks consisted of about a dozen each of plum, pear and apple trees in the immediate vicinity. They varied in degree of infestation from very slightly to about the same degree as the most extensively infested in the experimental orchard.

Conditions.— The trees were sprayed April 1 and 2. The buds were well swollen, but none of them had burst. During both

days the weather was cloudy with a high wind and occasional flurries of snow. The temperature varied from 31° to 36°. The mixture was boiled in barrels with live steam. McGowan and Seneca nozzles were used. As in the other orchards the trees were sprayed very thoroughly once and retouched twice. None of them were trimmed after the spraying was done. Owing to the very heavy winds much of the material was wasted, making the amount used per tree average nearly 2½ gallons.

The weather conditions during the thirty days immediately following the treatment were the same as given for Orchard II.

Effect on the trees.— In general the results in this orchard were the same as in the preceding. There was no apparent effect upon the trees except to delay the opening of the buds from three to six or seven days. The final examination made July 30 showed that the trees had made a better growth than for a number of years. There was no evidence of injury to bark, leaves or fruit. Where the wash had been the bark was usually clean and smooth. The foliage was better colored and more abundant, especially on the trees that had been most seriously infested, than for a number of years. It was much better than that of the infested checks. The fruit, especially, showed the effect of the treatment. It was as a rule clean, only an occasional one showing the marks of the scale. The crop of marketable fruit was largely in excess of any previous year in the history of the orchard.

Effect on the scale.— The frequent examinations made in this orchard during the summer showed the same general effect as previously reported. There were enough encrusted trees to give abundant data on the effects of the treatment on the scale. In this orchard as on Long Island it was apparent that the wash had had a secondary effect upon the young larvæ. Very few live scales could be found, but all that were found were upon the new growth. Only three fruits in the entire orchard were found with scales upon them. The fruit of some of the trees had been in previous years so badly infested as to be unsalable.

Effect of the weather upon the wash.— In this orchard the wash seemed to weather off somewhat more rapidly than in

either of the others. The trees remained white, however, for nearly two months, but when the last examination was made, July 30, it had weathered off in the most exposed places on the trunks and branches, especially on the sides toward the prevailing winds.

ORCHARD IV, PEARS.

This orchard is located within a short distance of Orchard III. It was planted at about the same time and consists of 22 Bartlett pear trees. Unlike the other orchard, it has been well cared for and most of the trees were vigorous. Only one was badly infested with the scale, the remainder were mildly infested.

The check trees, date of application, weather conditions and nozzles used were the same for this orchard as for Orchard III.

The only difference in the treatment of this orchard and those previously referred to was in the amount of the wash applied. The trees were sprayed very thoroughly once but were not retouched, the object being to determine whether one application, without retouching, could be made sufficiently thorough to be practicable, or whether it would be necessary in all cases to go over the trees a second time.

The results were better than had been anticipated. Although an occasional live scale was found, they were so few in number and the trees were uniformly in so much better condition than the check trees that the efficiency of the treatment was at once apparent. The treatment was evidently nearly if not quite as effectual as in the other orchards.

ORCHARD V, ONTARIO COUNTY, APPLES.

This orchard is located at Geneva. It was planted about 25 years ago and consists of 31 Baldwin apple trees of very large size. Little is known as to when the trees became infested, but when the experiments were made the scale was well distributed over each tree, the branches in each case being encrusted in places. During recent years the orchard has produced but little fruit, 80 bushels being the largest amount for one season, and most of this was rendered worthless because of being badly in-

fested and disfigured by the scale. The amount of infestation and size of trees especially fitted this orchard as a place to test the practicability of treating large trees for the scale.

Checks.— The checks consisted of four apple trees of the same age and variety located in an adjoining lot. Two were infested to about the same extent as the treated trees and the other two to a somewhat less degree.

Conditions.— The trees were sprayed April 23-26. The weather was cloudy and very windy during nearly the entire time. On the 24th a heavy gale was blowing during the entire day, resulting in much waste of material. During the evening of the 25th there was a heavy thunder shower of short duration and a light rain the following day. For all of the work in this orchard a barrel pump having two leads of hose was used and Seneca nozzles.

The buds were farther advanced on these trees than in any orchard previously treated. In many cases the buds had already burst and in some cases the leaves were well out, while in others only the tips of the young leaves were beginning to appear.

The method of treatment was the same as previously described, the trees being thoroughly sprayed once and retouched twice. Especial pains was taken to make the treatment thorough. Some of the worst infested branches were marked for final examination. When the spraying was completed the trees had the appearance of being whitewashed from the ground to the highest branches. Some idea of the thoroughness of the work is given in Plate XXXV, which is a view of a portion of the orchard soon after the spraying was finished. In Plate XXXVI a portion of one of the trees is shown. The picture was taken the same day that the tree was sprayed.

The weather during the thirty days immediately following the treatment was usually cloudy with several days of rain as follows: April 27 and 29, light rain; May 2, 4 and 5, light rain followed by a heavy rain on the 7th, lasting nearly all day; May 8 and 12, light rain followed by heavy showers on the 18th; light rains on the 19th, 20th and 22d, with heavy showers on the 23d and 24th; and a heavy rain on the 25th, lasting all the afternoon

Plate XXXIV.—Making the Lime-Sulphur-Salt Wash Over an Open Fire.

Plate XXXV.—Apple Orchard (Orchard V) Sprayed April 23–26 with the Lime-Sulphur-Salt Wash.

PLATE XXXVI.—SINGLE TREE SHOWING THOROUGHNESS OF TREATMENT.

Plate XXXVII.—Orchard V Showing Condition of Foliage in June.

Plate XXXVIII.—Tree in Orchard V Showing Wash Still Adhering Nov. 8. (Neg. by H. O. Woodworth.)

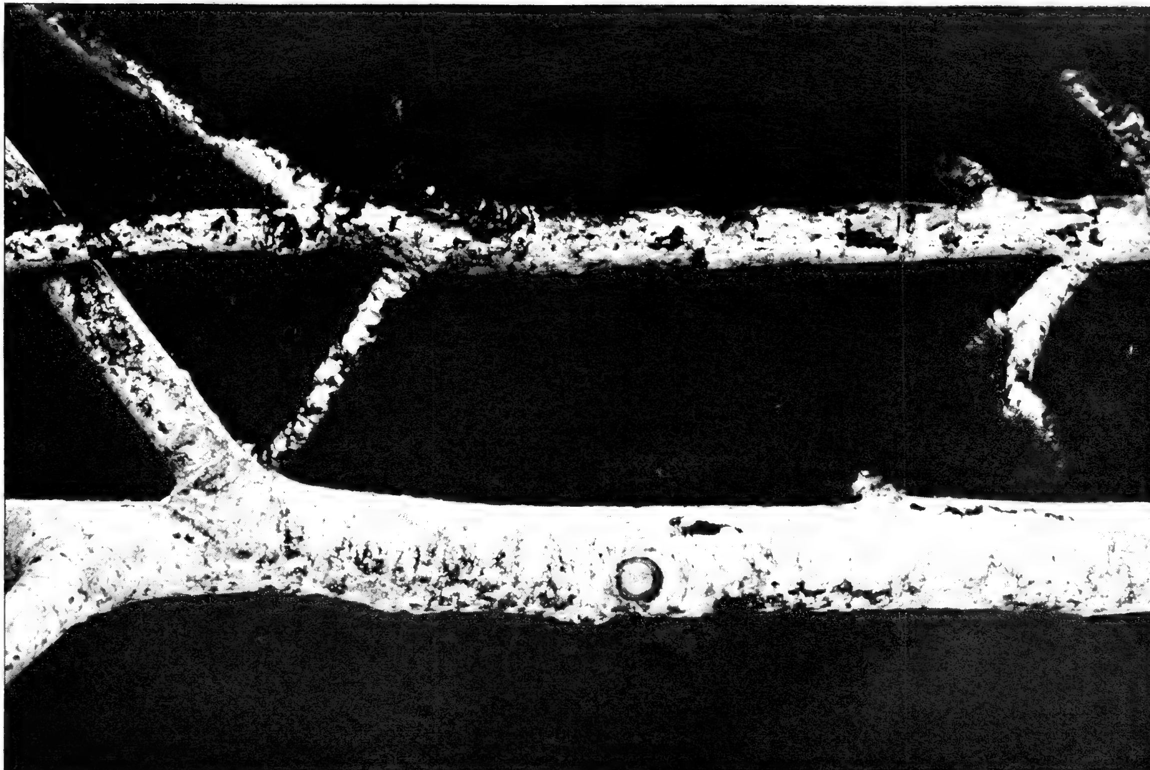

Plate XXXIX.—Twigs, Under Surface, from Same Orchard Showing Amount of Wash Adhering Nov. 8. (Natural Size)

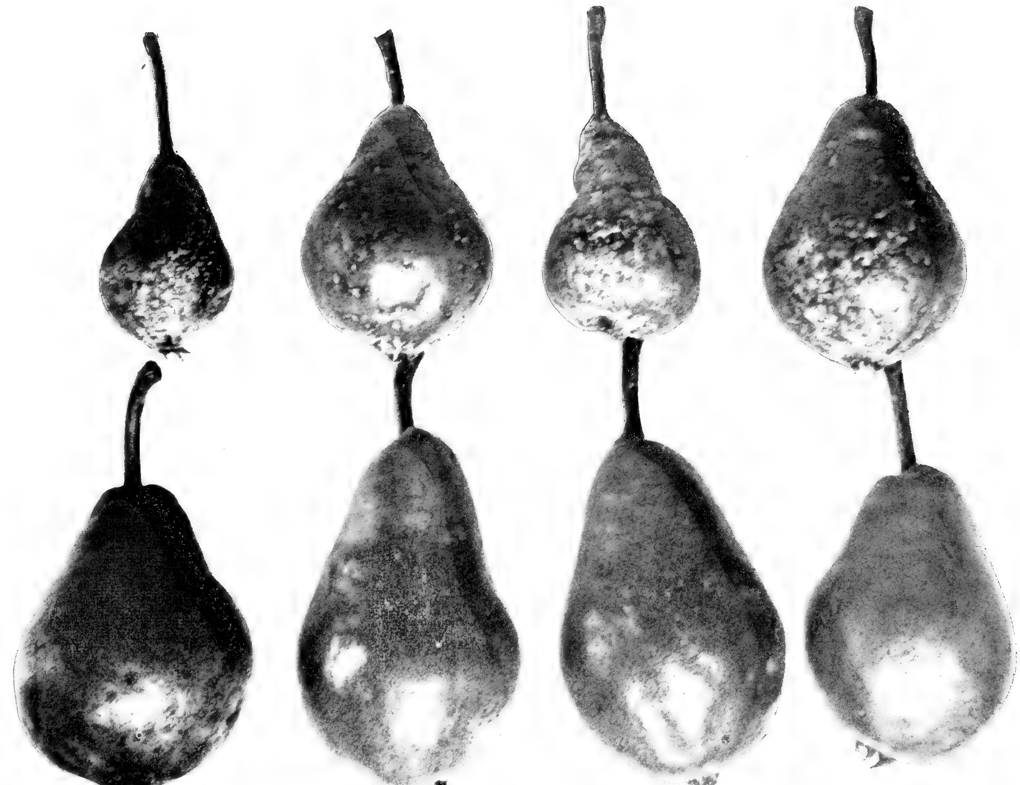

Plate XL.—Pears on Upper Row from Check Trees in Orchard VI. Lower Row from Treated Trees.

and most of the night, followed by moderately heavy showers the following day.

Effects on the trees.— It was at once apparent that many of the young leaves had been injured. Those that were most exposed were burned to a crisp, as were also the tips of the young leaves that were just appearing beyond the bud. The injury to the latter was of no practical importance as the injury did not extend into the buds. The only visible effect of the treatment upon the foliage was to delay its appearing about a week. When it was well started, however, it seemed to grow rapidly and in a short time was as abundant and vigorous as in any of the neighboring orchards. In fact the owner of the orchard stated that the foliage was more abundant and of better color than for some years past. Some idea of the condition of the foliage is given by Plate XXXVII, which is from a photograph of the orchard taken in June. It was also noticeable that the trees blossomed unusually full, a fact, of course, not necessarily due to the treatment, but important in showing that the wash did not injure the fruit buds.

The most significant fact in connection with the effect of the treatment upon the trees and especially upon the fruit buds was the amount and quality of fruit produced. The largest yield from this orchard during the past five years was 80 bushels, and during the past three or four years the fruit had been so badly infested with scale as to make it either unmarketable or of but little value. This year the yield was 275 bushels of clean marketable fruit. Except for slight injury by the codlin moth the fruit was uniformly of high quality, only an occasional apple being found that showed the marks of the scale, while in every case the fruit of the check trees was so badly infested with the scale as to be considered of too little value to harvest. Of special interest in this connection also is the fact that although the trees received no treatment except with the lime-sulphur-salt wash, the fruit from the treated trees was practically free from scab, while that of the checks was badly infested. The yield of the check trees also averaged much below that of the treated trees.

Effect on the scale.— The effect upon the scale has already been indicated. If the treatment had not resulted in killing nearly all the scales the fruit would have shown more of it. Careful examinations of the trees, however, failed to reveal more than a very few living scales and on most of the trees no live scales were found. An especial effort was made to test the wash in this orchard and to this end a number of the worst infested twigs were marked, with the result that no live scale was found on any of them. The prompt action of the wash was also indicated by the fact that the scales had apparently not grown since the treatment was made, but were killed while still in the hibernating stage.

Effect of the weather upon the wash.— This orchard afforded an excellent opportunity to observe the effect of the weather upon the wash as it is easily accessible from the Station. During the first few months there was practically no change in the appearance of the treated trees. During July the residue was noticed to be flaking off somewhat, especially on the smaller branches. With the exception of some of the small twigs and branches the trees remained well coated throughout the summer as indicated by Plate XXXVIII, which is from a photograph taken November 8. The trunk and limbs were of a whitish color from the presence of the residue of the wash still remaining. All of the trees in the orchard were as well covered with the white coating as this one at the time the picture was taken. The condition of the branches is indicated by Plate XXXIX, which shows the under surfaces of two branches cut and photographed November 8. These branches were cut almost at random and it is believed that they are typical of the branches of all the trees. As these pictures indicate, the trees throughout the orchard remained white during the entire summer in spite of the frequent and often heavy rains characteristic of the season.

MISCELLANEOUS APPLE TREES.

This lot consists of 15 trees in the Station apple orchard which were very slightly infested with the scale. They represent nearly fifteen different varieties. Most of them are young trees that have recently come into bearing. All were in excel-

lent condition and while there was not enough scale to furnish much data as to the effect of the wash upon the insect, their location was such as to make them very convenient for observation of the effects of the wash upon the trees and also its enduring qualities.

These trees were treated at about the same time as Orchard V, and under practically the same conditions. The results in general were also the same. There was no evidence of injury to the trees except that the young leaves which had burst from the buds were burned. The foliage was slow in appearing, but was finally as abundant as in other seasons. No trace of live scales were found on these trees after being sprayed.

ORCHARD VI, NIAGARA COUNTY, PEARS AND PEACHES.

This orchard is located on the lake road about three miles north of Lewiston. It consists of 212 trees of which 119 are pears and the remainder peaches. The pears have been planted about eight years and consist principally of Bartletts and a few Keiffers. The peaches have been planted four years and are about evenly divided between Smock and Yellow St. John. Thirty pears and 26 peaches were reserved for late spring treatment, leaving 89 pears and 68 peaches for these experiments. The orchard has been under excellent cultivation and except for the injury by the scale the trees were in good condition.

The pears were much more seriously infested than the peaches, 48 being encrusted from the lower part of the trunks to the smaller branches, while of the remainder, 29 were encrusted on some of the branches and the remaining 42 were slightly infested. The peaches were not as badly infested as the pears, only 22 being encrusted on any part of the tree, while the remainder were only slightly infested. Taken as a whole, however, the orchard furnished most excellent material for testing the efficiency of the wash as a remedy in badly infested orchards.

Checks.— The checks consisted of five pear trees selected from the orchard and representing as nearly as possible the condition of the pear trees throughout the orchard, and six peach trees in an adjoining block also representative of the conditions in the peach orchard.

Conditions.— The spraying was begun in this orchard April 7, but owing to bad weather it was not completed until April 16. The buds were well advanced and in many cases the young leaves were beginning to appear. During every day that the trees were being treated the work was delayed by rain. On the afternoon of April 8 rain began and continued in frequent showers until the morning of April 10. On this date the weather was very windy and threatening. The following morning was bright but in the afternoon a very heavy thunder storm prevented further work. The rain continued during the night and intermittently during Saturday morning. Heavy showers continued at frequent intervals until April 13. The heavy rains which came before the mixture was dry washed so much of it off as to make it necessary to go over the trees again.

The method of applying the wash was the same in this orchard as in the others. The trees were retouched twice and when the work was completed they had the appearance of being whitewashed. A barrel pump with two leads of hose and Vermorel nozzles were used in this orchard. The amount used, including the material washed off by the rains, averaged two and one-half gallons per tree.

The exact number of rainy days during the thirty days following the treatment was not ascertained. During April and May, however, there were frequent heavy showers accompanied by high winds. From April 15 to 30 there were frequent rains with especially heavy showers on the 28th, lasting most of the afternoon and evening, and several days of severe winds.

Effect on the trees.—As was the case with the apple trees, the opening leaf buds of both pear and peach trees were burned by the spray. The immediate effect of the treatment was also to delay the further development of the buds for about a week, thus giving the impression that the trees were injured. Later examinations showed that this was not the case. The foliage on the treated trees was uniformly much more abundant and of better color than that of the check trees or that of nearby orchards infested with the scale. There was not the slightest evidence of injury to the foliage or fruit buds. The amount of

marketable fruit produced by the treated pear trees was much in excess of previous years. On all of the treated pear trees there was a fair crop, while that of the check trees was so badly infested as to be unsalable. Some idea of the difference between the fruit of the treated and untreated trees may be obtained by referring to Plate XL. The trees from which the fruit was taken were carefully selected as being infested to about the same degree at the time the treatment was made. They were two of the worst infested trees in the orchard. The infested pears shown in the upper row were selected as representing the condition of the fruit on that tree. With the exception of the smallest pear these fruits averaged among the best on the tree. Those in the lower row were from the treated tree and correctly represent the average of the fruit on this tree, of which there was a fair crop. Throughout the orchard the fruit of the treated trees showed but little evidence of the scale. Only an occasional one could be found that was marked and these were disfigured to only a very slight degree.

Most of the peach trees were too young to produce much fruit, and hence there was little opportunity to test the effect of the wash upon the fruit buds. None of the peaches, however, showed any effect of the scale.

Effect on the scale.— The effect on the scale has already been indicated. The results here were the same as in the other orchards. The scales were promptly killed by the treatment and the young of those that escaped were evidently unable to find a place to settle down except on the new growth where an occasional live scale was found. The only trees upon which more than an occasional live scale could be found was on the western edge of the orchard which bordered on an orchard of very badly infested peach trees. The trees on the outside rows of the two orchards were so close together as to touch their branches. As a result the pear trees nearest to the infested peach trees were evidently infested from these trees, as young scales were found on them toward the middle of summer, and always in most abundance on the west side of the trees toward the peaches. A

few rows from these trees there was practically no scale, although the trees had been badly infested.

Effect of the weather upon the wash.— For about two months the trees remained nearly if not quite as white as when first sprayed. As late as June 21 Mr. F. G. Whitney, the owner of the orchard, who had carefully watched it, wrote that the sprayed trees did not seem to be affected by the rain. The only effects of the weather, so far as the general appearance of the trees was concerned, was the cracking and flaking off of the white coating on some of the branches, apparently the result of whipping in the wind. When the trees were finally examined in August the mixture was washed nearly off from the most exposed areas, giving the trees a dirty gray appearance. On most of the smaller branches it had disappeared altogether. In this orchard it was again demonstrated that while the wash adheres long enough to prove an effectual check to the scale in spite of heavy rains, it does not remain as long on pear and peach trees as upon apple, due apparently to the difference in the bark.

SUMMARY OF EXPERIMENTS IN SERIES I.

These experiments were conducted in six orchards located in different parts of the State as follows: On Long Island near Riverhead, in the upper Hudson Valley near Kinderhook, Columbia County, in western New York in Ontario County and near the extreme western part of the State in Niagara County. Seven hundred and ten trees were treated, of which 251 were peaches, including 11 varieties; 129 plums, Japan varieties; 284 pears, including about six varieties; and 46 large Baldwin apple trees. The work of spraying was begun on Long Island the last week in March and the last trees were sprayed in western New York about the middle of April. While the trees were being sprayed in two of the western New York orchards there were heavy rains before the work was finished. In all the localities the rainfall was heavy during the first thirty days after the treatment. With the exception of the one orchard at Kinderhook, which was not retouched, the trees were thoroughly sprayed once and retouched twice.

The effect upon the trees and scales was practically uniform. There was no evidence of injury in any of the orchards except on Long Island where the fruit buds of the Japanese plums were very slightly injured, due in all probability to the late date of treatment. In all cases the foliage was delayed for about a week but was uniformly as good or better than that of the check trees. All of the treated trees, with the exception above noted, bore a fairly good crop of fruit which was practically free from scale, only an occasional fruit being found that showed any evidence of the insect, while the fruit of the untreated trees was, as a rule, badly disfigured and unmarketable.

The effect upon the scale was none the less pronounced. The check trees in all the orchards showed an abundance of living scales on both the old and new growth, while on the treated trees only an occasional living scale was found. In every case, also, the immediate and secondary effects of the wash were apparent, the former being due to the soluble ingredients, as shown by the experiments with the infested apples, and the latter by the slowly soluble or insoluble compounds.

The wash adhered to the trees much better than was anticipated. All of them remained white for at least two months and several showed the white color plainly throughout the season. As would be expected, the comparatively rough bark of the apple trees held the wash much longer than the smoother barks of the other kinds.

Taken together the results are remarkably uniform and all point to the same conclusion, namely, that the lime, sulphur and salt wash is a safe and efficient remedy for the San José scale. But, although the fact that the experiments were conducted in different sections of the State and under somewhat different conditions, may make the results of more weight than if they had been confined to one or two orchards, it should be borne in mind that they represent but one season's experience and hence cannot be considered final but only indicative of the value of the insecticide.

LABORATORY EXPERIMENTS TO DETERMINE THE NATURE OF THE ACTION OF THE LIME-SULPHUR-SALT WASH UPON THE SAN JOSE SCALE.

The following experiments, although planned in part at Geneva, were largely conceived by Mr. Parrott and were finally carried out by him at the Ohio Agricultural Experiment Station.

Insecticides, broadly speaking, may be divided into two classes; first, the poisons or arsenical compounds which act only through the stomach, and, second, the contact remedies which when applied destroy by suffocation, through the penetration and sealing up of the insect's breathing organs. The lime, sulphur and salt wash belongs to this latter class, and is efficient in the destruction of softbodied and inactive insects; in that it contains coroding ingredients designated by the chemists as principally compounds of lime and sulphur and sodium and sulphur, and a large quantity of solid matter which when first applied is also caustic and when dried forms a very compact and adhesive coat, impenetrable by most of the scales. Which of the two ingredients is the more important and in what way it effects the destruction of the scales, is not known definitely. One authority* has offered an opinion that the wash is an indirect insecticide; in that it operates more effectually against the progeny than the parent insect "through some ingredient or ingredients that remained active, or became active, on the trees long after the application." In other words, providing there has been no extensive or rapid leaching by heavy rains immediately following, the wash, after application, has within it compounds which become soluble in light rains and dews, forming insecticides, which occasionally, if not daily for a reasonable time, not only immerse specimens already treated, but bathe, and perhaps destroy, the active larvæ and those which have settled, but have not had time to form their protective covering. That the calcium sulphide will directly kill the adult females and young has been proven conclusively; but of the insecticidal properties of the precipitate alone, or of the liquids upon the tree resulting from dews and rains, little is

*Lounsbury. *The Agricultural Journal*, 20: 771. (June 19, 1902).

definitely known. To ascertain the effect of these last factors liberal coats of the wash were applied to vertical glass plates 18x14¾ inches in size, which when dried were atomized with water, the product being caught and applied to infested apples under the conditions as outlined in the various experiments appended below. The chemical and mechanical processes, if any, taking place, were thought to approximate the phenomena upon a treated tree under ordinary conditions. This method was adopted because of the ease of obtaining the liquid and precipitates, and of isolating a known number of scales and their progeny to prevent colonization of young from other scales.

EXPERIMENT NO. I.

The principal object of this experiment was to determine whether the soluble ingredients and the precipitates obtained by spraying dry lime-sulphur-salt wash with water, possess insecticidal properties and, if so, how long these properties are retained. In Series I of this experiment the glass plate, upon which the lime-sulphur-salt wash has been sprayed until a heavy coating was formed, was allowed to dry under ordinary conditions in the laboratory for one hour. In Series II the time allowed for drying was extended for each successive apple tested. as shown in the table, thus furnishing evidence as to the number of washings, or rains, required to exhaust the wash of its insecticidal value.

After drying, the plate used in Series I was thoroughly washed with water from an atomizer. The water was applied at the rate of one ounce of water for each ounce of wash applied to the plate. The water was so applied as to drench all parts of the plate and was drained off into a small receptacle. This method was followed in all cases. The solution was then applied to the infested apples at the rate of 17 drachms to each apple, which was greatly in excess of the amount that would adhere to the apple. The character of the wash is best shown by its appearance after it had dried on the apples as described in the tables.

The following tables summarize the treatment with the soluble products of the wash secured by submitting the dried lime-sulphur-salt wash to one thorough drenching with water.

TABLE I.— TREATMENT AND RESULTS WITH SOLUBLE AND OTHER INGREDIENTS OF THE LIME-SULPHUR-SALT WASH ON SCALE-INFESTED APPLES.

FIRST SERIES.

Number of apple.	Scale.		Date of treatment.	Character of deposit resulting from treatment.	Record of Larvae Born.																Total number larvae born.	Total number scales in experiment.	Percentage killed by treatment.
	Adult females.	Young.			August			September															
					29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	9	90	Aug. 28	A thin film over the entire apple, but no heavy deposit.	2	5	2	1	0	0	0	0	0	0	1	2	1	0	1	0	15	114	5
2	4	25	Aug. 28	Heavy deposit forming crust over entire apple thick enough to cover the scales.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	97
3	3	17	Aug. 28	Heavy deposit. Most of the young scales were covered.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	95
4	5	242	Aug. 28	Deposit heavy, especially about the calyx, but many young scales were not covered by it.	0	0	1	0	0	0	5	0	0	0	0	0	0	1	5	8	20	267	19
5	9	70	Aug. 28	Deposit very heavy on all parts of the apple. All scales covered.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79	96
6	8	74	Aug. 28	Slight deposit.	1	0	0	3	1	1	2	0	0	0	0	5	1	1	0	2	17	99	30
7	1	11	Aug. 28	Slight deposit.	0	0	0	2	1	1	0	2	5	1	0	2	1	12	3	2	32	44	11

DETAILED RESULTS.

At the time of final examination, September 26, the apples considered in Table I, Nos. 1 to 7, showed the following effects from the treatment under Series I:

Apple No. 1.— Twenty-five living males, 22 living adult females, 61 living young. The remaining 6 scales were dead.

Apple No. 2.— One adult female alive with 15 dead larvæ beneath her scale. Eight well-developed embryos were also found in this female. The remaining three adult females were dead and their bodies were much shrunken, with no evidence of young. They were evidently killed upon the application of the wash. All of the young scales were killed.

Apple No. 3.— One female was found alive with 3 living and 46 dead young under her scale. Seventeen well developed embryos were found in this female. The remaining scales were dead.

Apple No. 4.— Twenty-four larvæ dead upon the coating or crust formed by the treatment; one female alive with 1 living and 26 dead larvæ beneath her scale; one female alive with 5 living and 9 dead larvæ beneath her scale; two females alive that had not produced young. There were also 214 living young scales on portions of the fruit lightly covered with the wash. They were under the thin deposit.

Apple No. 5.— One female alive with 35 living and 7 dead young beneath her scale; one female dead with 47 dead young beneath or near her scale; one female dead with 5 dead young beneath her scale; one female dead with 19 dead young beneath or near her scale; one female dead with 14 dead young; two females dead that had produced no young; two living females, one of which had two living larvæ. All of the 70 young scales were killed.

Apple No. 6.— One female alive with 20 dead and 3 living young; one female alive with 41 dead and 7 living young; one female alive with 5 dead and 6 living young; thirteen larvæ were found dead on the surface of the apple and 53 young scales that had succeeded in settling down were alive. The remaining scales were dead.

Apple No. 7.— One adult female, containing 30 well-developed embryos, alive; 12 living males; 36 living and 6 dead young scales; 11 living females showing first molt.

TABLE II.—TREATMENT AND RESULTS WITH SOLUBLE AND OTHER INGREDIENTS OF THE LIME-SULPHUR-SALT WASH ON SCALE-INFESTED APPLES.

SECOND SERIES.

Number of apple.	Scales. Adult females.	Scales. Young.	Date of treatment.	CHARACTER OF TREATMENT.	Record of Larvae Born, October 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Total number larvae born.	Total number scales in experiment.	Percentage killed by treatment.
39	21	1250	Oct. 11	Three oz. of wash sprayed on glass plate and left 1 hour. Plate was then sprayed with 2 oz. of water with an atomizer, and 10½ drachms of yellow colored liquid was drained off. This was allowed to settle. The liquid only, 9 drachms in all, was applied to apples 39, 40 and 41. A very slight deposit was formed on each apple.	0	2	4	1	0	1	0	0	2	6	4	0	0	1	..	..	21	1292	99
40	34	570	Oct. 11	Same as No. 39	1	0	0	0	1	1	1	1	0	4	4	1	0	0	..	..	14	618	23
41	34	780	Oct. 11	Same as No. 39	0	0	0	0	3	3	1	0	1	0	0	0	0	0	0	..	8	822	52
42	36	398	Oct. 11	Treated with 1½ drachms of the precipitate obtained by the settling of the liquid used upon apples 39, 40 and 41. A very slight deposit was formed upon the apple.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	434	21
43	30	597	Oct. 11	Check; no treatment	0	9	19	7	6	6	5	2	1	9	0	0	0	2	0	0	66	693	23

44	23	896	Oct.	11	Check; no treatment............................	18	6	9	20	13	7	8	9	3	7	0	0	0	6	0	0	106	1025	43
45	30	620	Oct.	12	Three oz. of wash were sprayed upon a glass plate and allowed to dry for 12 hours. Then sprayed plate with 1 oz. of water and obtained 2½ drachms of liquid and ½ drachm of precipitate. Applied liquid only to apples 45 and 46 A very slight deposit was formed on each apple.	..	..	22	12	16	8	10	0	8	15	0	0	0	13	0	0	104	754	30
46	19	460	Oct.	12	Same as No. 45............................	..	..	1	0	0	1	0	0	1	3	0	0	0	2	0	0	8	487	1
47	7	318	Oct.	12	Three oz. of wash dried on glass plate 20 hours. Then sprayed it with 1 oz. water, and obtained 2 drachms liquid and 2 drachms precipitate. Applied liquid only to apples 47 and 48. Very slight deposit on apples.	..	..	4	0	0	10	12	0	1	0	0	0	0	5	0	0	32	357	62
48	17	470	Oct.	12	Same as No. 47............................	..	..	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2	489	71
49	15	463	Oct.	13	Three oz. of wash upon glass plate 32 hours. Then sprayed it with 1oz. water, and obtained 6½ drachms liquid and ½ drachm precipitate. Applied liquid to apples 49 and 50. Deposit very slight on apples.	..	..	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	478	87
50	25	514	Oct.	13	Same as No. 49............................	..	..	1	0	0	0	1	0	0	0	1	0	0	0	0	0	3	542	62
51	21	473	Oct.	14	Three oz. of wash upon glass plate 72 hours. Then sprayed it with 1 oz. of water and obtained 6½ drachms of liquid and ½ drachm precipitate. Applied liquid only to apples 51 and 52. Deposit very slight on apples.	..	..	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	495	31
52	4	262	Oct.	14	Same as No. 51............................	..	..	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	269	95

TABLE II.—(*Concluded*).

Number of apple.	Scales.		Date of treatment.	Character of treatment.	Record of Larvae Born.																Total number larvae born.	Total number scales in experiment.	Percentage killed by treatment.
	Adult females.	Young.			October																		
					12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27			
53	23	460	Oct. 15	Three oz. of wash upon glass plate 96 hours. Then sprayed it with 1 oz. of water and obtained 7 drachms of liquid, but no precipitate. Applied liquid to apples 53 and 54. Deposit very slight upon apples.	..	..	..	4	0	8	0	0	3	3	0	0	0	0	0	0	10	493	74
54	7	225	Oct. 15	Same as No. 53............................	..	..	..	0	2	4	1	4	9	0	0	0	0	0	3	5	28	250	89

DETAILED RESULTS.

At the time of final examination of the apples considered in Table II, which received the various treatments included in the second series, they were in the condition noted below:

Apple No. 39.— Five adult females alive without young; 5 dead without young; 18 adult females dead with 5 to 32 dead young; 9 nearly mature females alive; 916 in black, or hibernating stage, dead; remainder dead.

Apple No. 40.— Four adult females alive without young; 12 adult females alive with 2-16 living young; 14 adult females dead with no young; 2 adult females dead with 8 to 10 dead young; 1 adult female alive with 25 well-developed embryos but no young; 1 adult female alive with 3 dead young; 1 adult female alive with 27 dead and 4 living young; 3 females of 2d molt stage dead; 1 female of 2d molt stage alive; 360 with scale in black stage alive; 24 young, with scale in white stage, dead, and 96 alive; remainder alive.

Apple No. 41.— Twelve adult females alive without young; 1 adult female alive with 15 young; 19 adult females dead with no young; 1 adult female alive with 47 well-developed embryos but no young; 3 adult females alive with from 5 to 14 dead and 2 to 5 living young; 12 nearly full-grown females alive; 50 male propupæ alive and 13 dead; 312 with scale in black stage alive; remainder dead.

Apple No. 42.— Thirteen adult females alive without young; 2 adult females dead without young; 4 adult females dead with 3 to 32 dead young; 16 adult females with anal segments raised above deposit on apple; 1 female alive with 7 dead young; 12 nearly mature females alive; 315 with scales in black stage alive; remainder dead.

Apple No. 43.— Sixteen adult females alive without young; 6 adult females dead without young; 4 adult females dead with 3 to 13 dead young; 2 adult females alive with 2 to 4 dead young; 115 nearly mature females alive; 403 with scales in black stage alive.

Apple No. 44.— One female alive without young; 21 adult females dead with no young; 1 adult female alive with 4 well-

advanced embryos; 583 with scales in black stage alive; remainder dead.

Apple No. 45.— Thirteen adult females dead without young; 19 adult females alive without young; 514 with scales in black stage alive; remainder dead.

Apple No. 46.— Three adult females alive without young; 12 adult females dead without young; 2 adult females alive with 9 living young; 1 adult female dead with 3 dead young, and 37 living young with scale in white stage; 443 with scales in black stage alive; remainder dead.

Apple No. 47.— One adult female alive with 5 living young; 4 adult females dead with 6 to 13 dead young; 5 adult females with anal segments raised above deposit on apple; 5 adult females alive with 0 to 7 dead young; 2 nearly mature scales dead; 119 with scales in black stage alive; 7 nearly mature scales alive; remainder dead.

Apple No. 48.— Three adult females alive with 0 to 19 living young; 6 adult females dead without young; 5 adult females alive with 0-1 dead young; 1 adult female alive with 7 dead and 4 living young; 1 adult female alive with 7 dead young; 3 immature females alive; 126 with scales in black stage alive; 4 young scales turned a reddish color by spray alive; 40 young scales turned a reddish color by spray, dead; 2 propupæ dead; remainder dead.

Apple No. 49.— Fifteen adult females dead with 0 to 25 dead young; 1 adult female alive with 22 well-advanced embryos; 26 females in 2d molt stage alive; 33 with scales in black stage alive; remainder dead.

Apple No. 50.— One adult female dead with 5 dead young; 27 adult females dead; 209 with scales in black stage alive; remainder dead.

Apple No. 51.— Fifteen females alive without young; 5 females dead with 2 dead young; 1 female alive with 3 living young; 325 with scales in black stage alive; remainder dead.

Apple No. 52.— Nine adult females alive with no young; 1 adult female alive with 3 young; 1 adult female dead with 5 dead young; 246 with scales in black stage alive; remainder dead.

Apple No. 53.— Nineteen adult females alive with no young; 4 adult females alive with 2 to 7 living young; 3 adult females dead with no young; 7 young scales just settling down alive; 316 with scales in black stage alive; 27 young scales turned reddish by wash, of which 18 are alive; remainder dead.

Apple No. 54.— Ten adult females alive with 1-8 living young; 1 adult female dead; 12 with scales in white stage alive; 202 with scales in black stage alive; remainder dead.

CONCLUSIONS.

The above tables show that a large percentage of the insects were killed immediately by the spray obtained by atomizing with water a coat of lime, sulphur and salt, one hour after its application. The results at final examination clearly indicate that many adult females were destroyed either before or in early maternity and were entirely prevented or instantly checked in the production of offspring, and that many larvæ and immature scales died immediately after treatment as a result of the soluble ingredients present in the spray. Equally apparent is the destructive effects of the insoluble ingredients or precipitates. It is not always possible in each case to distinguish the effects of the soluble from the insoluble ingredients, especially in the destruction of living larvæ beneath the mother scale. But it does strongly appear that the precipitates are efficient insecticides in that they act mechanically by confining the larvæ to the mother scale (apple No. 42), and presenting a surface impenetrable to the larval mouth parts (apples 4 and 6). The precipitates, unless very abundant, do not appear to destroy mature female scales, and when present in small quantities will not prevent immature forms from developing to maturity.

Sprays secured from the wash seventy-two hours after application to a plate (apple 52) possessed soluble insecticides which were destructive to immature forms, while later sprays were much less efficient. The experiments in this series do not furnish evidence of the maximum time the soluble ingredients are present as active insecticides. With the amount of dilution of

the spray, and the quick evaporation after its application, the results obtained would hardly form a good basis for determining the probable length of time that soluble ingredients are present and act as efficient insecticides in a wash applied under ordinary orchard conditions. This would certainly vary with the amount of rain and sunshine following the application.

EXPERIMENT II.

The principal object of this experiment was to determine how long after its application the wash would retain its insecticidal properties when submitted to severe daily drenching with water. Incidentally the direct insecticidal properties of the soluble compounds were brought out. The results obtained should indicate the conditions upon treated trees, especially during a wet season.

For the experiment a glass plate, of the size previously stated under Experiment I, was flooded with 3 ounces of lime-sulphur-salt wash and allowed to dry thoroughly. The coating of the wash thus formed was thoroughly dry in 24 hours and was then sprayed with one ounce of water applied with an atomizer. The residue was caught as before and immediately sprayed upon infested apples. This was continued on each of six successive days, the same glass plate with the wash receiving the same treatment with water each time, but the residue was applied to a different apple each day, so that the first apple (No. 8 of Table III) received the residue obtained by spraying the plate the first time, the second apple (No. 9 of Table III) the residue obtained by spraying the plate the second time, and so on until all the apples were treated. A summary of the treatment is given in the following table:

TABLE III.— TREATMENT AND RESULTS WITH SOLUBLE AND OTHER INGREDIENTS OF THE LIME-SULPHUR-SALT MIXTURE OBTAINED BY SUCCESSIVE TREATMENTS OF DRIED WASH WITH WATER.

Number of apple.	Scales.		Date of treatment.	CHARACTER OF TREATMENT.	Record of Larvae Born.																	Total number larvae born.	Total number scales in experiment.	Percentage killed by treatment.
	Adult females.	Young.			August			September																
					29	30	31	1	2	3	4	5	6	7	8	9	10	11	18	20	24			
8	3	45	Aug. 28	Apples sprayed with product obtained by first spraying of glass plate. Product thus obtained was clear with white precipitate. It formed a crust over the skin of the apple which completely concealed the scales.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	..	..	..	0	48	100
9	2	25	Aug. 28	Sprayed with product obtained by spraying the plate the second time. Uneven coat of precipitate formed on apple.	3	10	2	1	0	2	5	2	0	0	1	0	4	0	..	..	..	30	57	91
10	12	62	Aug. 29	Sprayed with product obtained by spraying the plate the third time. Flocculent precipitate formed but apple showed but slight evidence of the treatment.	..	2	0	1	3	2	2	0	1	0	0	5	5	3	..	..	..	24	98	33
11	31	54	Aug. 30	Sprayed with product obtained by spraying the plate the fourth time. Precipitate slight and but very little was apparent on the treated apple	..	..	20	8	32	36	7	16	39	58	14	12	30	20	..	..	..	292	377	20

TABLE III.—(*Concluded*).

Number of apple.	Scales.		Date of treatment.	CHARACTER OF TREATMENT.	Record of Larvae Born.																Total number larvae born.	Total number scales in experiment.	Percentage killed by treatment.
					August			September															
	Adult females.	Young.			29	30	31	1	2	3	4	5	6	7	8	9	10	11	18	20	24		
12	40	100	Aug. 31	Sprayed with product obtained by spraying the plate the fifth time. Apple showed but slight evidence of the treatment.	..	..	..	3	6	0	0	0	5	12	0	3	1	5	..	..	..	37	177	23
13	17	54	Sept. 1	Sprayed with product obtained by spraying the plate the sixth time. Only a very slight precipitate was apparent upon the apple.	..	..	..	..	0	2	1	16	4	0	0	8	23	19	..	..	..	73	144	34
14	25	29	Sept. 2	In this case the dry wash on glass plate was rubbed with finger to detach some of precipitate. Then sprayed and the product thus obtained sprayed on apple where formed a thin film.	..	..	..	..	..	3	2	0	5	12	6	1	0	7	4	5	..	45	99	20
15	25	162	Sept. 3	Treated as No. 14 but enough of precipitate secured to form hard crust on apple.	..	..	..	..	..	..	0	0	2	4	0	0	0	1	5	0	0	12	199	66

DETAILED RESULTS.

The apples whose treatment is noted in Table III showed these conditions at the time of final examination, September 27:

Apple No. 8.— Seventeen larvæ dead upon surface of the crust; 1 adult female dead with several larvæ beneath its scale; 1 adult female dead, no young; 1 adult female dead with 14 dead young beneath the scale. All of the young scales were found dead beneath the crust.

Apple No. 9.— Eighteen larvæ dead upon the surface of the crust; 1 female alive with 29 dead and 8 living larvæ beneath its scale. This female had succeeded in raising its scale above the crust; 1 adult female alive with 12 dead and 8 living young beneath its scale; 5 young that had begun to form scales were found alive. They were on parts of the apple thinly covered by the deposit. The remainder of the scales were dead.

Apple No. 10.— Four young larvæ were found moving about upon the surface of the apple, 11 were found dead; 10 adult females alive, no young; 1 adult female alive, with 5 active larvæ beneath her scale; 1 female dead, no young; 1 male nearly mature; 3 males alive; 52 young scales alive, remainder dead. September 2, 10 of the adult females were observed projecting the posterior margins of their bodies from beneath their scales.

Apple No. 11.— Thirty-eight larvæ dead; 25 adult females alive and 6 dead; 276 young scales developed to the black stage alive; remaining scales dead.

Apple No. 12.— Many larvæ maving about on the apple; 87 young and 37 adult females alive, also 16 that had just begun to form the scales; 3 adult females dead.

Apple No. 13.— Nine adult females dead with several dead larvæ under their scales; 8 adult females alive; 28 young that had begun to form scales together with 59 others alive. Remaining scales dead.

Apple No. 14.— Seventeen adult females with no young alive; 4 adult females alive with 3 to 15 dead larvæ under their scales; 4 adult females dead; 58 living and 12 dead that had developed to the black stage; 42 that were beginning to form the scale alive. Remaining scales dead.

Apple No. 15.— Fourteen adult females alive with from 8 to 12 living and 3 to 6 dead larvæ beneath their scales; 11 adult females dead with no young; 14 young just forming scales (white stage) slightly covered with wash, alive; 39 scales, black stage, alive. Remaining scales dead.

CONCLUSIONS.

For this series of experiments the wash that had been allowed to dry for 24 hours on the glass plate was sprayed with water every day for six days. Each day the residue thus obtained was sprayed upon an infested apple (Nos. 8-13). The results are very pronounced. The residue obtained from the first application of the water to the dried wash, killed all of the scales or 100 per ct. This residue undoubtedly contained much of the soluble ingredients as well as a small amount of the insoluble or slowly soluble ingredients which formed a crust on the apple. As was to be expected, the products of the succeeding applications of water to the wash on the glass plate were much weaker in soluble ingredients and had correspondingly less effect upon the scale as shown by the percentage killed on apples 10 to 13. The same result is shown on apple 14. When more of the precipitate was obtained, as was the case for apple 15, fewer young were produced and more of the scales were killed.

While it is difficult to determine the exact effect of the soluble ingredients and heavy precipitates of the wash, as it was impossible to know in all cases the exact condition of the scales on the treated apples, the above table and results give further evidence that the soluble ingredients act as a direct contact poison, killing the adults and young, while the insoluble or slowly soluble compounds act indirectly as a mechanical barrier to the development of the young scales.

EXPERIMENT III.

This experiment was principally for the purpose of determining the effect of an excessive amount of precipitates (or insoluble or slowly soluble ingredients of the wash) upon the scale. This has a bearing upon the relative value of a large or small excess of lime in the wash.

A glass plate of the usual size was coated heavily three times with the wash and allowed to dry thoroughly. The plate was sprayed with one ounce of water from an atomizer each morning from September 1 to 15. The residue obtained each day was sprayed at once upon three infested apples as shown in the table.

TABLE IV.— SUMMARY OF TREATMENT WITH PRECIPITATES FROM LIME-SULPHUR-SALT WASH.

Number of apple.	Scales: Adult females.	Scales: Young.	Date of treatment.	CHARACTER OF TREATMENT.	Record of Larvae Born. September 2	3	4	5	6	7	8	9	Total number larvae born.	Total number scales in experiment.	Percentage killed by treatment.
17	3	188	Sept. 1–15	Apple sprayed each day for 12 days. A heavy deposit formed about the calyx and stem and a film on the remainder of the apple.	2	3	1	0	4	0	0	0	10	201	99
18	34	237	Sept. 1–15	Apple sprayed each day for 15 days, when it was covered with a heavy deposit.	13	28	14	8	10	3	6	0	82	353	89
19	32	306	Sept. 1–15	Treated same as No. 18. Deposit became very thick, especially about the calyx.	2	8	1	3	7	0	0	0	21	359	92

DETAILED RESULTS.

At the time of final examination, September 27, Apples Nos. 17 to 19, whose treatment is noted in Table IV, showed the following results from the applications:

Apple No. 17.— One adult female dead with 44 dead young beneath her scale; 2 adult females alive with 16 to 23 dead larvæ respectively beneath their scales. Remainder of scales dead.

Apple No. 18.— Seventy-eight dead larvæ on the surface of the deposit covering the apple; 17 adult females alive and from 15 to 30 dead and from 5 to 10 active larvæ; 5 adult females alive, two of which had raised their scales above the crust; 10 adult females dead; 4 nearly mature females on sides of apple alive; 4 scales that had reached the black stage were also found alive.

Apple No. 19.— Twenty-one larvæ were found dead under the heavy deposit about the calyx; 15 adult females living with from 2 to 7 dead and 3 to 11 living larvæ under their scales; 13 young alive that had passed the first molt. Remaining scales dead.

CONCLUSIONS.

The mechanical effect of a heavy deposit of precipitates upon the development of the scale is well brought out in this experiment. While the soluble ingredients of the wash evidently killed many of the scales at the time of the first and second treatments, the later treatments, which consisted largely of the precipitates, killed a higher percentage of the scales, as shown by the table. The fact also that many of the young scales were found held securely under the crust and others dead upon it, further indicate the mechanical effect of the heavy deposit. The larvæ that were found dead upon the crust were unable to find a suitable place to settle down. Their delicate mouth parts could not penetrate the coating of precipitate. In this experiment the heavy deposit acted as a mechanical obstruction to the emerging and settling down of the young and resulted in killing a fair percentage of the mature females and a majority of the immature scales, a much larger percentage in the case of the latter than in any of the previous experiments.

EXPERIMENT IV.

The object of this experiment was to imitate a condition often occurring on a tree, especially where the wash is not evenly applied. The condition referred to is that of a number of scales in close proximity to a coating of the wash but which have not been touched by it. By applying water frequently in the form of a fine spray, a condition often occurring in orchards during wet seasons was brought about. Naturally some of the ingredients of the dried coating of the compound would be washed upon the scales and by this means it could be determined to what extent the treatment thus brought about could be depended upon to kill the scale in various stages of development. This has a direct bearing upon the degree of thoroughness necessary in treating infested orchards with the lime-sulphur-salt wash. It is to be noted, however, that, in this case, although the apples were sprayed very carefully and very gently it is not improbable that the daily treatment of water may have killed some of the young scales.

For the experiment three apples were selected that were infested at the stem and blossom ends only. The sides of the apples were well coated with the wash, which was allowed to dry. They were then sprayed with water from an atomizer every day for fifteen days.

A summary of the treatment is given in the following table:

Table V.— Effect of Materials Washed out from Lime-Sulphur-Salt Mixture upon Adjacent Scales not Directly Touched by the First Application.

Number of apple.	Scales.		Date of treatment.	CHARACTER OF TREATMENT.	Record of Larvae Born.										Total number larvae born.	Total number scales in experiment.	Percentage killed by treatment.
	Adult females.	Young.			September												
					2	3	4	5	6	7	8	9	10	11			
20	20	50	Sept. 1–15	Apples sprayed every day for 15 days. The mixture, forming a band about sides of apple, was slowly washed to stem and blossom ends covering the scales.	2	5	1	1	0	3	2	8	1	1	24	94	78
21	4	37	Sept. 1–15	Same as No. 20	2	8	1	0	0	0	0	0	0	0	11	52	73
22	3	100	Sept. 1–15	Same as No. 20	0	0	0	0	0	0	0	2	0	0	2	105	80

DETAILED RESULTS.

The apples in Experiment IV, Nos. 20-22, showed the facts noted below, when finally examined, September 27:

Apple No. 20.— Three adult females alive, with from 2 to 14 dead and from 0 to 12 living young under their scales. All of the remaining scales dead.

Apple No. 21.— Four adult females alive, with from 3 to 16 dead and from 0 to 3 living young under their scales; 3 scales of hibernating stage alive. Remaining scales dead.

Apple No. 22.— Two adult females dead, with 5 and 9 dead young respectively under their scales; 1 adult female with 3 living young under her scale; 16 females recently past first molt alive. Remaining scales dead.

CONCLUSIONS.

That the treatment prevented normal reproduction and growth of the scales is apparent from the comparatively few young produced and the large percentage of scales in all stages of development that were killed. The destruction of the young may have been due in part to the excessive amount of water, but from the fact that many did not succeed in escaping from beneath the parent scale, and also from the fact that many of the adult scales as well as those that had recently settled down or had already reached the hibernating stage were killed, it is apparent that the poisonous and mechanical properties of the wash were responsible for a large part of the work of destruction.

EXPERIMENT V.

This experiment and the next were conducted in large part as checks upon the preceding experiments. In these two experiments the soluble and insoluble ingredients of the wash were tested separately. In addition to acting as a check the two experiments furnish further data upon the action of the soluble ingredients and the precipitate upon the scales. For this experiment the soluble ingredients only were used.

The material for treating the four infested apples selected was secured by coating another one of the glass plates with a heavy

coating of the lime-sulphur-salt wash. The coating of wash was dried immediately in a drying oven and then exposed all day to the bright sunlight. The plate was then thoroughly sprayed with water at the rate of one ounce of water to each ounce of wash. The product thus obtained was carefully drained off into a suitable receptacle and allowed to settle. The liquid was then drawn off and sprayed upon the four apples, as shown in the following table:

TABLE VI.— EFFECT OF SOLUBLE PORTION OF LIME-SULPHUR-SALT WASH ON SCALE-INFESTED APPLES.

Number of apple.	Number of Scales.		Date of treatment.	CHARACTER OF TREATMENT.	Record of Larvae Born. September							Total number larvae born.	Total number scales in experiment.	Percentage killed by treatment.
	Adult females.	Young.			6	7	8	9	10	11	18			
23	30	57	Sept. 6	The solution which was sprayed upon the apple with an atomizer did not stain the skin. There was no deposit.	3	12	10	15	4	7	19	60	147	56
24	63	110	Sept. 6	Same as No. 23	40	36	19	32	36	51	42	256	429	32
25	23	137	Sept. 6	Same as No. 23	32	21	8	15	26	37	52	193	353	30
26	53	350	Sept. 6	Same as No. 23	8	17	44	18	41	60	12	200	603	0

DETAILED RESULTS.

The condition of apples Nos. 23 to 26, Table VI, at time of final examination, September 28, is noted below.

Apple No. 23.— Twenty-three adult females alive, with 7 to 10 dead larvæ under the scale of each; 7 adult females dead; 17 dead larvæ, free on surface of apple; 42 scales at hibernating stage alive. Remaining scales dead.

Apple No. 24.— Fifty-three adult females alive; 240 young alive; 80 scales dead and remainder missing.

Apple No. 25.— Eighteen adult females alive; 20 young scales in hibernating stage and 210 larvæ alive. Remaining scales dead or missing.

Apple No. 26.— Fifty-three adult females living; apple literally covered with young scales in all stages of development.

CONCLUSIONS.

The treatment of the plate as previously described seems to have brought about marked chemical changes, doubtless in the breaking down of the sulphides, so that the effect of the product obtained from spraying the plate seems to have had little apparent effect upon the scales. A comparison of this lot with those scales that had not been treated shows that the percentage of living scales and the offspring produced during the period under observation was no greater than in this case. Likewise, the results of this experiment are somewhat contradictory of experiments I and II. But the results of these latter are so conclusive that the apparent contradiction by Experiment V must be explained by the difference in treatment.

EXPERIMENT VI.

This experiment was the same as No. V, except that the precipitate instead of the liquid was used. Enough of the liquid was used, however, to form a thick paste with the precipitate.

The object of this experiment was to determine the effect of the precipitate upon the scales when used practically alone. The results are given in Table VI.

TABLE VII.— EFFECT OF PRECIPITATED PORTION OF LIME-SULPHUR-SALT WASH ON SCALE-INFESTED APPLES.

Number of apple.	Number of Scales. Adult females.	Young.	Date of treatment.	CHARACTER OF TREATMENT.	Record of Larvae Born. September 6	7	8	9	10	11	18	22	24	28	29	Total number larvae born.	Total number scales in experiment.	Percentage killed by treatment.
27	30	35	Sept. 6	Heavy precipitate in form of thin paste sprayed on all parts of apple. It formed a crust when dry.	2	10	3	0	0	0	1	0	0	0	0	16	81	20
28	20	160	Sept. 6	Same as No. 27, but with heavy crust about calyx and stem and a thin crust on sides of apple.	0	0	0	0	7	0	18	15	0	35	13	88	268	81
29	24	175	Sept. 6	Same as No. 28	0	0	0	0	0	0	14	0	19	13	8	54	253	75
30	15	90	Sept. 6	Same as No. 28	0	0	3	0	0	0	0	10	7	13	12	45	150	40

DETAILED RESULTS.

The detailed results, supplemental to those in Table VII, showing the effect of the treatment on apples 27 to 30, up to the time of the final examination, September 30, appear below:

Apple No. 27.— Thirty adult females alive; 35 scales in hibernating stage alive; 13 larvæ dead; remainder missing.

Apple No. 28.— Eighteen adult females alive, with from 10 to 30 dead and from 1 to 3 living larvæ under the scales. Six of the adult females had raised their scales above the crust formed by the wash; 34 young, with scales in white stage, alive; eighteen of these had lifted their scales so that their bodies could be seen; 71 larvæ dead upon the surface of the crust formed by the wash. Remainder of the scales dead or missing.

Apple No. 29.— Twenty-six adult females living, with from 3 to 11 dead and from 2 to 9 living larvæ under their scales; 43 dead larvæ on the sides of the apple where the crust was thin; 36 young scales, that had passed second molt, had raised their scales somewhat but were alive. Remaining scales dead.

Apple No. 30.— Six adult females alive with from 3 to 6 dead and 0 to 4 living larvæ under their scales; 35 dead larvæ on surface of crust formed by wash; 87 young females alive, although many were so located as to be under a heavy crust, 22 of these females, located where the crust was thin, had raised their scales somewhat.

CONCLUSIONS.

In these experiments the adults were but little affected by the heavy precipitate while the young scales were, as a rule, unable to withstand it. The fact that the young scales were killed in greatest numbers on those parts of the apple which were most heavily covered with the precipitate further indicates the mechanical effects of the heavy crust in killing the young scales either by smothering them or by preventing their securing food. In the previous experiments, notably I and II, there were soluble compounds possessing some insecticidal value associated with the precipitate, so that in many instances it was a matter of doubt to which of the two to credit the destruction of the

larvæ. In the previous experiment, No. V, it seemed evident that the treatment of the scales was inefficient because of the lack of these same insecticidal compounds. As the precipitate in this experiment, No. VI, was the residue from No. V, it is safe to assume that the destruction of the scales in the present experiment is to be credited to the mechanical effects of the precipitate and not to any soluble compounds present with it. The low percentage killed, shown by the table (apples 27 and 30), is due to the smaller number of young.

CHECKS.

A series of experiments shown in the following table was carried out as checks to the foregoing experiments. Apple No. 1 was treated with a thin coating of whitewash, thus supplying the conditions, so far as the mechanical effect of a practically neutral heavy wash is concerned, prevailing in those experiments in which the precipitate was abundant, especially Nos. I, II, IV and VI. The only important difference was that in the case of the checks the whitewash acts as a purely mechanical mixture while it is possible, in most of the above experiments, that some poisonous qualities of the insoluble ingredients of the wash may have an influence in destroying the scales. Apples Nos. 2 and 3 were sprayed every day with water for fourteen days to determine the effect of the water alone upon the scale, and thus to act as a check upon experiments in which the soluble ingredients alone of the wash were used. Apples Nos. 4, 5 and 6 were not treated and were thus a check upon all of the experiments.

TABLE VIII.—RESULTS OF CHECK TREATMENTS.

Number of apple.	Scales. Adult females.	Scales. Young.	Date of treatment.	CHARACTER OF TREATMENT.	Record of Larvae Born. September 7	8	9	10	11	12	13	14	15	16	17	18	19	28	Total number larvae born.	Total number scales in experiment.	Percentage mortality.
1	50	30	Sept. 6	Apple covered with a thin coat of whitewash......	2	5	0	0	8	1	11	14	12	2	0	0	17	..	72	152	60
2	5	•215	Sept. 6–20	Sprayed apple every day with water from an atomizer for 14 days.	2	0	0	0	0	5	0	1	3	2	0	2	2	..	17	237	65
3	18	182	Sept. 6–20	Same as No. 2..............................	10	13	0	0	3	2	8	0	14	6	0	3	8	..	67	267	59
4	3	16	Sept. 6	Not treated................................	2	0	8	5	1	12	8	0	0	3	0	7	12	..	58	77	36
					October 12	13	14	15	16	17	18	19	20	21	22	23	24	25			
5	30	596	Oct. 11	Not treated................................	0	9	19	7	6	6	5	2	1	9	0	0	0	2	66	692	23
6	23	896	Oct. 11	Not treated................................	18	6	9	20	13	7	8	9	3	7	0	0	0	6	106	1025	43

DETAILED RESULTS.

Apple No. 1.— Forty-two adult females alive, with from 8 to 20 dead larvæ under their scales; 18 scales in hibernating stage were found under thickest crust, 5 were alive, remainder dead; 14 other young scales were found alive; also 39 dead larvæ on surface of the crust.

Apple No. 2.— Five adult females alive; 57 scales in hibernating stage alive and 140 dead; 22 young larvæ just forming scales alive; 7 larvæ dead on side of apple beneath the crust.

Apple No. 3.— Five adult females alive, with from 1 to 7 and 2 to 8 living larvæ under their scales; 13 adult females alive with no young; 104 scales in hibernating stage, of which 38 were dead; 26 young just forming scale alive. Remaining scales dead.

Apple No. 4.— Three adult females alive; 14 scales in hibernating stage alive; 7 dead; 35 larvæ just beginning to form scales alive; 7 larvæ dead on side of apple beneath the crust. Remaining scales dead.

Apple No. 5.— Sixteen adult females alive with no young; 6 adult females dead with no young; 4 adult females dead with 3 to 13 dead young; 2 adult females alive with 2 to 4 dead young; 115 nearly mature females alive; 403 scales in hibernating stage alive. Remaining scales dead.

Apple No. 6.— One adult female alive, with no young; 21 adult females dead with no young; 1 adult female alive, containing 4 well-developed embryos; 583 scales in hibernating stage alive. Remaining scales dead.

CONCLUSIONS.

The checks serve as a basis of comparison with those apples treated as described in the various experiments. The conclusions to be drawn from these statistics are of no value except as compared with those gathered from the lots under experiment, which are reserved for the general summary. Attention, however, might be called to Apple 1, Table VII, as showing that lime in itself does possess some value as a wash, especially in preventing the escape of larvæ from beneath the mother scale and apparently in suffocating immature scales. The treatment

with water seems to have had but little effect upon the production of larvæ or otherwise upon more mature forms or upon the larvæ themselves. Apples Nos. 4, 5 and 6 present an interesting record of the daily production of young, of the percentages of living and dead immature scales, and of extreme variation in the ratios of living and dead adult females, all of which affords an excellent basis for the interpretation of the results obtained in Experiments I to VI.

GENERAL SUMMARY AND CONCLUSIONS, EXPERIMENTS I TO VI.

In these experiments 50 apples were used. The number of scales upon each apple varied from 1 adult and 11 young to 63 adults and 1,250 young, an average number sufficient to give reliable results. In most of the experiments three or four infested apples were used.

The infested apples selected were perfectly sound and showed considerable larval activity. The fact also that larvæ were being produced on the fruit at the time of the experiments was good evidence of the age and condition of the mother scales. The fair presumption is that most of them were alive, but it was impossible to determine the percentage. To have determined this would have necessitated the injury or destruction of most of the scales. Hence, in the interpretation of the results, allowance must be made for probable injury to the insects in the handling of the fruit, although it was handled with great care, and also for variation in degree of parasitism[7] and death from other natural causes.

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[7]Dr. L. Reh in a paper entitled *Untersuchungan an Amerikanischen Obst Schildlausen* in *Mittheilungen aus den Naturhistorischen Museum* (Hamburg?), Vol. XVI, reports considerable difference in the parasitism of the San José scale upon imported American fruits. A summary given by Dr. L. O. Howard in U. S. Dept. Agr. Div. of Ent. Bul. No. 22, N. S., is as follows: Two hundred and fourteen (33.49 per ct.) living and 425 (66.51 per ct.) dead specimens of *Aspidiotus perniciosus* were found. Of the dead specimens, 63 were "eaten out" (killed by insect enemies), equal to 9.06 per ct. of all specimens, and 156 (equal to 22.44 per ct. of all specimens) were infested with fungi. More than 30 per ct. of all imported San José scales arrived infested with parasitic insects or fungi.

In a recent publication (Bul. 71) Dr. S. A. Forbes reports that 50 per ct. of the immature were dead before treatment in the spring. He considers that this mortality was due to the low vitality of the trees. Similar observations showing great mortality were made last spring at this Station on this and other closely allied orchard scales with the result that no satisfactory cause could be found for the condition unless it was parasitism or climatic conditions.

Any one who has had occasion to examine into the condition of a large number of scales appreciates the losses in numbers through this source alone. This is a point well worth bearing in mind if a statistical determination during the dormant period of the scale is to be the criterion of the efficiency of washes just previously applied rather than the condition of these same trees at the close of the following breeding season of the scale. For this reason the season was chosen when the larvæ were most active, the white and black scales numerous, and there was evidence of living adult scales. That each experiment might contain scales of an average condition the apples were divided into lots of from 3 to 20 each.

The experiments furnish valuable data upon the insecticidal properties of the wash in showing that, upon application, the soluble ingredients cause the death of all the scales with which they come in contact, and that when the wash has dried there still remain soluble ingredients destructive to scale life, the duration of the insecticidal properties of which is largely determined by the degrees of heat and moisture immediately following the application.

Experiment I, second series, shows unmistakably marked insecticidal properties in the wash three days after its application, and to a much less extent on the fourth. In Experiment II it is shown that one good drenching of the wash as by a heavy rain, following an application, causes a wasteful and excessive leaching away of these desirable compounds, and that the length of time that these are retained in the wash is dependent upon the number and degree of subsequent drenchings. In Experiment V there is strong evidence that conditions of heat affect the wash also, higher temperatures assisting in the breaking down of the soluble ingredients to less efficient ones, and lower temperatures retarding such action, thus extending the time in which these ingredients can act as efficient insecticides.

Attention is also directed to the results with the insoluble or slowly soluble ingredients that formed a crust when dry over the surface of the fruit. It was apparent that the effect of these insoluble ingredients was largely mechanical in that the young

were prevented from escaping from beneath the mother scale, or if they did escape, from finding a suitable place to settle down. The insoluble deposit also killed the young scales that had settled down but had not yet formed the mature scale. It is therefore largely through these ingredients that a prolonged action of the wash is to be expected. The more of the heavy deposit on the tree the less rapidly the soluble ingredients will be washed away and the more prolonged the mechanical effects.

In general these experiments bear out the results obtained in the field experiments, namely, that the wash clearly has a direct and prompt, largely chemical, effect and a secondary, or mechanical, effect upon the scale.

II. SUMMER TREATMENT WITH LIME-SULPHUR COMPOUNDS.

During the past summer experiments have been conducted in two orchards situated in Westchester and Niagara counties with the lime and sulphur compound in various proportions as shown in the following summaries. The principal objects of the experiments were to determine the propositions of the lime and sulphur which could be used safely and also whether summer spraying could be made practicable as a method of combating the scale.

EXPERIMENTS IN NIAGARA COUNTY.

These experiments were conducted in Mr. Whitney's orchard described on page 299. Fifty-three trees were sprayed, 27 of which were Bartlett and Keiffer pears and the remainder Smock and Yellow St. John peaches. Two of the pear and one of the peach trees were badly encrusted with the scale, eight of the pears and nine of the peaches badly infested, but to a somewhat less degree, while the remainder were slightly infested. Two pears were left as checks.

The trees were treated June 14, one thorough application being made, followed by another application, where needed, to insure thorough treatment. An average of about one and one-fifth gallons of the mixture was used for each tree. The weather on the date of the treatment was bright and warm with but little wind.

All of the trees were well leaved out. The weather during the four weeks following the treatment was cool with quite frequent showers. There was an especially heavy shower June 21.

The mixture, which was made after the following formula, was boiled for two hours in an iron kettle and applied hot. It will be observed that in this formula both the lime and sulphur are used in less quantities in proportion to the water than in the formula for the winter wash:

Lime, unslaked	25 pounds.
Sulphur, ground	14 pounds.
Water	60 gallons.

RESULTS.

The effect upon the trees was at once apparent. The leaves began to shrivel almost immediately and in a few days were badly burned and ready to drop off. Nearly all the leaves were killed. When the orchard was visited August 7 new leaves had formed and the trees were in fairly good foliage. The fruit buds showed no evidence of injury, as the crop of fruit compared favorably with the checks.

The scales were killed on every limb that had been thoroughly treated. The presence of the foliage naturally prevented very thorough treatment of the smaller branches and in a few cases live scales were found scattered about on the small branches that had escaped thorough treatment.

EXPERIMENTS IN WESTCHESTER COUNTY.

This orchard is one of the largest in the county. The trees selected are Burbank plums and were badly encrusted with the scale. They averaged about eight years of age and until the scale became sufficiently abundant to cause injury, which was not until this season, were in excellent condition.

FIRST SERIES.

Two series of experiments were made in this orchard. The first included only four trees and was considered preliminary to the second. As will be observed the amount of lime was varied

for the first two trees and the sulphur and lime for the second two, the principal object being to determine to what extent the sulphur and lime could be reduced and yet retain the adhering and killing qualities of the mixture. The mixture was prepared in the usual way in each case and boiled not less than two hours. The trees were sprayed July 1. The weather was bright and very warm. The three following days were among the warmest of the season, and the rainfall during the following month was above the average.

Tree 1. This tree was encrusted with the scale on the trunk and all of the larger branches. The fruit, which was abundant, was also badly infested. The wash for this tree was made after the following formula:

Lime, unslaked	10 pounds.
Sulphur, ground	5 pounds.
Water	45 gallons.

Tree 2. This tree was infested to about the same degree as No. 1. In this case five pounds more of lime was used with the same amounts of sulphur and water.

Tree 3. This tree and No. 4 were infested to somewhat less degree than Nos. 1 and 2 but the trunks and most of the larger limbs were well encrusted. The fruit, although less seriously injured was so badly infested as to be unmarketable. The ingredients of the wash were used in the following proportions for this tree:

Lime, unslaked	10 pounds.
Sulphur, ground	2½ pounds.
Water	45 gallons.

Tree 4. The same formula was used for this tree except that 15 pounds of lime was used in place of 10 pounds.

RESULTS.

The trees showed the effects of the treatment almost immediately. Within three days the foliage of Nos. 1 and 2 was badly wilted and the trees soon dropped all of their leaves. Further than this there was no evidence of injury. The fruit remained on the trees. On both trees the scales were killed except on

a few of the small twigs that were not well sprayed. Nos. 3 and 4 were not affected as much as the other two trees; although in both cases the leaves dropped prematurely. The result upon the scales was also the same.

These experiments therefore indicate that only a comparatively small amount of sulphur and lime in proportion to the water is needed to kill the scale but that even when much reduced in quantity it cannot safely be used upon the foliage.

SECOND SERIES.

The second series was made in September, the trees being sprayed from September 3 to 5. Eight Japan plum trees and three peach trees, badly encrusted with the scale, were used for these experiments. The weather was clear with a light wind except on the second morning when there was a light shower.

In these experiments six plum trees and three peach trees were sprayed with mixtures in which the sulphur was reduced to a minimum as shown in the formula below. The remaining two plum trees were sprayed with whitewash only. This arrangement was for the purpose of making parallel tests with the lime and sulphur to determine as far as possible to what extent the sulphur can be reduced and still kill the scale and also whether there will be any appreciable effect on the scale if the sulphur is omitted entirely. The experiments in detail are as follows:

Trees 1, 2 and 3 were sprayed with a mixture made after the following formula:

Lime, unslaked	10 pounds.
Sulphur, ground	1 pound.
Water	45 gallons.

Trees 4, 5 and 6 were sprayed with a similar mixture except that 15 pounds of lime was used.

Trees 7, 8 and 9 were sprayed with the same mixture as numbers 1 to 3 except that copper sulphate at the rate of one pound to each 11 gallons of the mixture was added.

Tree 10 was sprayed with whitewash made of 10 pounds of lime to 45 gallons of water and tree 11 with whitewash in which 15 pounds of lime to 45 gallons of water was used.

RESULTS.

The trees were examined frequently, the final examination being made November 18. None of the trees showed evidence of injury. The scales were killed on trees 1 to 9 except as in previous instances upon an occasional branch which escaped thorough treatment. The scales upon trees 10 and 11, however, which were sprayed with whitewash only, did not seem to be affected. They were as abundant as upon the check trees.

The adhesiveness of the washes used in these experiments was not so pronounced as in the case of the winter treatment, but in all cases except where the whitewash alone was used the trees remained white for several weeks. The whitewash weathered off rapidly.

III. EXPERIMENTS IN MAKING A LIME-SULPHUR WASH WITHOUT BOILING.

The principal objection to the use of the lime-sulphur washes is the expense and inconvenience, in most cases, of boiling. A number of experiments have been made at the Station recently with a view to devising a method that will produce a satisfactory wash without boiling with fire. In these experiments strong alkalies were used to dissolve the sulphur, including Babbitt's potash and caustic soda. The alkalies were used in various proportions with the sulphur but from one-fourth to one-half pound of alkali to each pound of sulphur seemed to be enough. Caustic soda, ground, is probably to be preferred to the potash as it seems to be as effectual and is cheaper. The salt being omitted, as apparently having no value in this method of preparing the wash, the formula for 60 gallons would include the ingredients given on page 394 with from 5 to 10 pounds of caustic soda (or potash) in place of the salt.

In the preparation of the mixture the lime was slaked, preferably with warm water, and while it was slaking vigorously the sulphur, which had been made into a thin paste, was added and thoroughly mixed with the slaking lime. The caustic soda was then added, with water as needed, and the whole stirred thoroughly. As soon as the chemical action had ceased the required amount of water, preferably hot water, was added and

the mixture was ready for use. It is not improbable that this method will require modification, but as far as tested it promises to prove satisfactory.

It is yet too early to make a definite statement as to the practical value of this or similar methods of making the wash. The mixture thus produced, however, has the general appearance of the wash made in the usual way, but although field tests are under way we have not yet satisfactorily demonstrated the safety or efficiency of the wash when made in this manner. The subject is presented at this time, therefore, as merely suggesting the possible value of this method. Should the method prove efficient after further trial, more definite statements will be made in a later publication.

IV. SPRAYING EXPERIMENTS WITH OTHER WASHES.

A number of compounds which have been recommended as remedies have been tested during the past season, both on Long Island and in Ontario County as follows:

TESTS ON LONG ISLAND.

These experiments were made in the orchard in which the other Long Island experiments were conducted. The trees were sprayed April 27 in the same manner as in the lime-sulphur experiments. The same check trees were also used. Three compounds were tested as follows:

RESIN WASH.

California formula.— Four peach trees, Early Crawford, Late Crawford and Elberta, and two Japan plum trees were selected for this test. Two of the peach trees were badly encrusted with the scale. The remainder were mildly infested. The wash was made after the following formula:

Resin	8 pounds.
Caustic soda	2 pounds.
Fish oil	1 pint.
Water	40 gallons.

The resin, caustic soda and fish oil were boiled in a small amount of water for two hours and then diluted with warm

water to 40 gallons. This wash sprays fairly well but is somewhat troublesome in clogging the machinery, especially the nozzles, unless kept warm. It forms a smooth glossy coat on the bark.

Results.—Although the trees were examined several times during the season, there was no evidence of injury. A fair percentage of the scales were killed, but so many survived the treatment that before cold weather the trees had become quite badly infested again. The wash did not remain more than two or three weeks on the trees.

Station formula.— This wash is the result of a number of attempts to make a resin wash without boiling. In this case the ammonia dissolves the resin. It is only necessary to stir the mixture about 15 minutes or until all of the resin is dissolved. The principal objection to this wash is the fact that it gums the machinery somewhat, especially if allowed to stand for a day or two in the tank. It is much beter to empty the tank and clean the machinery by pumping through a little diluted ammonia or boiling hot water before putting the machine away. The wash was tested at two strengths, the stronger containing one-half pound of resin to each gallon of the mixture, and the weaker one-fifth pound to the gallon. The formula is as follows:

Ammonia 26°	$1\frac{1}{3}$	gallons.
Fish oil	1	quart.
Resin	8	pounds.
Water	4	gallons.

As soon as the resin is thoroughly dissolved add water to make 16 gallons of the mixture for the strong and to make 40 gallons for the weak.

Six peach trees were sprayed with the weak and six with the strong mixture. One tree in each lot was badly encrusted with the scale and the others were moderately infested.

Results.—The wash sprayed well, as it formed a soapy mixture. It dried quickly on the trees, leaving a smooth polished surface. No injury was caused in either case and the scales were evidently killed wherever the wash came in contact with them, as only an occasional live scale was found.

TESTS IN ONTARIO COUNTY.

The experiments were conducted in a small peach orchard near Geneva. It had been planted about four years but had become very badly infested with the scale. The trees selected for the experiments were encrusted on the trunks and larger branches. They were sprayed June 27 when the young leaves were well out. The weather at the time of treatment was fair with but little wind. Four trees were sprayed with the ammonia-resin compound, Station formula, both strong and weak, with practically the same results as on Long Island except, as was expected, that the young leaves were somewhat injured. Two trees were also sprayed with the California resin wash with practically the same results as on Long Island. In this case also the young leaves were burned somewhat.

LIME-WATER-KEROSENE WASH.[10]

This wash was made after the formula given by Marlatt and prepared as directed by him in the bulletin above referred to. The formula and directions are as follows:

Fresh lime	4 pounds.
Water	5 gallons.
Kerosene	1 gallon.

" Slack the lime slowly with small quantities of water in order to get a creamy solution. When thoroughly slacked dilute to five gallons, add one gallon of kerosene, and churn until emulsified (one or two minutes)."

This mixture was applied with especial care. The tree was thoroughly covered. Considerable difficulty was experienced in applying the wash evenly as the oil separated from the water very quickly, and made heavy streaks on the trunk and branches. It remained white on the tree for a few days but soon turned a dirty gray and disappeared almost entirely in a few weeks.

Results.— The trees were not injured, and at the time of the final examination, August 7, the tree was nearly freed from the scale; the occasional surviving scales found evidently escaped being reached by the spray.

[10]Suggested by Professor Galloway and published by C. L. Marlatt in U. S. Dept. Agr., Div. Ent. Bul. 30, N. S., p. 37.

AMMONIA-CASEIN WASH.

This wash was made by the Station formula as follows:

Water	1 gallon.
Casein	1 pound.
Ammonia 26°	1 pint.

The ingredients were mixed and the whole boiled about an hour or until the casein was divided into very fine particles suspended in the solution. The casein was used for the purpose of comparison with resin as a base.

Results.— The wash sprayed well and formed an excellent evenly distributed and highly polished varnish on the bark. It remained on the tree during most of the summer, gradually weathering off late in the season. There was no evidence of injury to the tree except that the young leaves were slightly burned. The scales were evidently killed wherever reached by the spray. Many were found glued to the bark.

LIME-SULPHUR-SALT WASH AND CASEIN.

The lime-sulphur-salt wash was prepared in the usual way and, while boiling, the casein wash, as prepared above, was added at the rate of one pound of casein to each gallon of the wash. The object was to determine if casein could not be used to increase the adhesive qualities of the lime-sulphur-salt wash.

Results.— One tree was treated. The casein separated from the rest of the mixture and hence it was difficult to apply evenly. As was expected, the lime, sulphur and salt killed the young leaves and seriously injured the tender twigs.

LIME-SULPHUR-SALT WASH, LIQUID ONLY.

The wash was made in the usual way and allowed to stand until all the heavy precipitate had settled. The liquid was then drained off and sprayed upon a tree. This experiment is parallel to some of the experiments with infested apples, page 434, testing the effect of the soluble ingredients of the wash upon the scales, and in its effect upon the scale bears out the results.

Results.— The young leaves were badly burned and the tips of the smaller branches were also burned somewhat, due un-

doubtedly to using the solution too strong. No live scales were found although the tree was badly infested at the time of treatment and was carefully examined twice during the summer.

LIME-SULPHUR-SALT WASH AND BORDEAUX MIXTURE.

The lime-sulphur-salt wash was made in the usual way and after removing from the fire a solution of copper sulphate in water was added in the proportion of one pound of copper sulphate to 11 gallons of the mixture. The result was a heavy greenish wash. One tree was sprayed.

Results.—Although the wash was quite heavy it sprayed easily and formed, when dry, a heavy greenish coating on the bark. This combination adhered as well if not better than the lime-sulphur-salt wash alone. The leaves and twigs were injured somewhat; as was to have been expected, for the wash was used at winter strength. The treatment was evidently a success in killing the scales as no live scales were found, although the tree was one of the most extensively infested of any in the orchard, and was carefully examined three times during the season.

POTASH-SULPHUR WASH.

This wash has been successfully used in California and for this experiment was made as directed. The formula and directions are as follows:

Caustic soda	$\frac{3}{4}$ ounce.
Potash	$\frac{3}{4}$ ounce.
Sulphur	$2\frac{1}{4}$ ounces.
Whale oil soap	1 pound.
Water	5 gallons.

The ingredients were boiled together for one and one-half hours and applied hot. Two trees were treated.

Results.— There was no evidence of injury to the trees except a slight burning of the foliage. The trees were examined twice, May 14 and August 7, but only an occasional scale was found on either date. The wash weathered off within two or three weeks and left the bark clean and smooth.

SUMMARY OF RESULTS.

These experiments, although including but a few trees, are sufficiently extensive to indicate final results. No attempt was made to compare the cost of making the different mixtures as none of them are expensive. The principal difference in the cost of making lies in the apparatus required and the amount of boiling necessary. Where boiling can be avoided considerable inconvenience and expense is saved.

Comparing the resin washes, the one made after the Station formula proved as effectual in killing the scale as the other, did not injure the trees when applied before the leaf buds burst, and can be made more conveniently and economically, as it does not require boiling and the cost of the ammonia is slight. The casein has a slight advantage over the resin in adhesive qualities, but it is probably not sufficient to warrant the additional expense.

None of the compounds tested gave any better results than the lime-sulphur-salt and bordeaux mixture, and this has the additional advantage, which is of much practical importance, of combining both the insecticidal and fungicidal properties. By combining the two, therefore, the necessity of making an extra treatment for the scale is avoided.

DISCUSSION OF RESULTS AND CONCLUSIONS.

The experiments recorded in this bulletin represents but one season's work and, therefore, should be considered as preliminary. Any conclusions that may be based upon such experiments are necessarily provisional, and this is all that is claimed in this case. It may be noted, however, that, in general, the results in the East with the lime-sulphur-salt wash have been favorable, and as this is the case with the present experiments, they bear out results already obtained.

As stated on a previous page, the wash has proven a satisfactory remedy in California. Its power to destroy the scale there has been demonstrated. It now remains to determine whether this can be said of it under our eastern climatic condi-

tions. The experience of recent years, however, has shown that the real problem is not the extinction of the San José scale, as this is evidently an impossibility, but its control. Any wash or other treatment, therefore, designed to be used as a remedy for the scale should be judged on this basis.

In the experiments herein reported various washes were used. At the close of each series a summary is given, and hence it is unnecessary to go into detail here. The principal experiments were with the lime-sulphur-salt wash. The facts that the experimental orchards were well distributed over the State, and that, with the exception of the Long Island orchard, the wash was subjected to unusually severe tests of washing rains soon after its application, add materially to their value.

The laboratory experiments to determine the nature of the action of the wash upon the scales bear out the conclusions indicated by the orchard experiments, namely, that the wash kills the scales in two ways; directly through its soluble compounds and probably very soon after coming in contact with them, thus acting as a contact poison; and indirectly through its slowly soluble or insoluble compounds by forming a crust which apparently smothers the young insects, often preventing their escape from beneath the mother scale, or by preventing the active larvæ that have been produced by females that escaped being hit by the spray from finding a suitable lodging place upon the bark. The importance of the crust formed by the precipitates is an argument in favor of the liberal amount of lime, as the excess of lime aids materially in the formation and stability of the crust and with the other precipitates delays the washing away of the soluble compounds.

The experiments further indicate that the lime-sulphur-salt wash, or a lime-sulphur wash, may be combined with a solution of copper sulphate, forming bordeaux mixture, and thus act as both an insecticide and fungicide. It should be applied a short time before the buds burst in the spring, a desirable time for the first treatment with the bordeaux mixture. This is one of the most important features of the treatment with this wash, as it does away with the necessity of a special spraying apparatus and a separate treatment for the scale.

The results with the other washes were not such as to indicate a superiority over the lime-sulphur-salt wash. The summer treatment was successful as far as summer treatment with a spray for this insect is likely to be. It was found that on plum trees the sulphur should be reduced to a minimum to prevent burning the foliage. One pound of sulphur to each ten pounds of lime was found sufficient to kill the scales during the summer and did not seriously injure the leaves. The salt was omitted. The difficulty, however, of thoroughly spraying the bark of trees that are in foliage makes summer treatment with washes unsatisfactory as a rule.

The following conclusions may be considered as indicated by the experiments:

1. No special apparatus is required for the application of the lime-sulphur-salt wash. A machine suitable for spraying bordeaux mixture will be found satisfactory. Care should be taken to protect the hands and face while spraying with the wash.

2. The wash does not spread readily upon the bark, and hence much pains should be taken to hit every part of the tree.

3. Through its soluble ingredients, the wash acts directly as a contact poison, killing the scales soon after coming in contact with them; and indirectly, through its insoluble or slowly soluble ingredients, as a mechanical preventive to the development of the young. The efficiency of this phase of the wash is greatly aided by the presence of an excess of lime.

4. The lime-sulphur-salt wash may be combined with bordeaux mixture either in the proportions known as the Oregon wash or by adding a dilute solution of copper sulphate to the formula given in this bulletin in the proportion of one pound of copper sulphate to each eleven gallons of the diluted wash. This method is preferred.

5. The wash should be applied early in the spring, a short time before the buds begin to swell.

6. The wash apparently does not injure apple, pear, peach and plum trees (the varieties included in the experiments), the only effect being to delay the foliage about a week.

7. All things taken into consideration, the lime-sulphur-salt wash promises to be a highly efficient wash for the treatment of trees infested with the San José scale under eastern conditions. It appears to be safe and reliable and is comparatively cheap. Should these indications be borne out by future experience a cheap and comparatively easy method of controlling the scale will be assured. In case, also, that it is found that the wash can be successfully made without delay and expense of boiling it will add materially to its practical value. It must not be expected, however, that the scale will be exterminated even by thorough treatment, but it may be held in check sufficiently to prevent important injury.

ACKNOWLEDGMENTS.

The spraying experiments recorded in this bulletin could not have been carried out under the favorable conditions which attended them if it were not for the hearty co-operation of the owners of the orchards in which the experiments were made, and others. Acknowledgments are especially due to Mr. F. A. Sirrine of the Station staff, Mr. H. E. Wells of Riverhead, Long Island; Mr. Edward Van Alystyne, Mr. Wm. Hotaling, Mr. Risedorph, Mr. Van Buren of Kinderhook, Messrs. White and Rice of Yorktown, Mr. Frank Stevenson of Geneva and Mr. F. G. Whitney of Youngstown.

REPORT

OF THE

Horticultural Department.

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[1]Resigned August 5, 1902.

VARIETY TEST OF STRAWBERRIES.*

O. M. Taylor.

SUMMARY.

The late frosts and cool moist weather doubtless modified the yield of many varieties of strawberries in the Station plats in 1902. Their relative productiveness might therefore be somewhat different in a normal season.

The most productive varieties were: Crescent, *Riehl No. 29,* Monitor, Manokin, Beder Wood, *Howard No. 2,* and *Riehl No. 26,* ranking in the order named.

Before growing any new variety extensively, it is best to try a few plants only. Among the newer varieties worthy of trial are: Bennett, *Henry,* Joe, Kansas, Monitor, Prof. Fisher, *Riehl No. 26, Riehl No. 31* and Rough Rider. Marshall and Sample, though not new in some localities, could also be added to this list. All of these kinds except Bennett and *Henry* maintained their size to the close of the picking season.

Beder Wood and Crescent gave the largest early yield. Johnson Late was the latest variety to ripen. It lacks in color and firmness. At the last picking, Nettie gave larger berries than any other variety. Monitor has many desirable features, but lacks somewhat in firmness and quality. Prof. Fisher should be planted closer than other varieties, because it makes very few runners. *Henry* and Sample should be sprayed, because they are subject to leaf blight, commonly called "rust."

INTRODUCTION.

In this bulletin are reported tests of some of the recent introductions in strawberries, and of a few standard sorts for comparison. In the case of most of the varieties the plants were

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obtained directly from the originator or introducer in order to be the more certain of having them true to name. In other cases the plants were taken from the Station beds and were of established identity.

The fact that no variety does equally well on all soils and in all localities should be borne in mind when using this bulletin. The notes which follow simply indicate the behavior of the different varieties on our soil and under our local conditions. Under different conditions some of the varieties would be better. Nevertheless the results obtained with a variety here may be taken in a general way as an index to its value elsewhere, and the success of a variety here certainly would warrant giving it a place in trial grounds in other localities.

NOTES ON TEST.

The plants used in these tests were all set in the spring of 1901. The soil on which the tests were made is a rather heavy clay loam, well tile-drained and sloping slightly towards the south. During the season of 1900 a crop of corn was grown on this land. Early the following spring it received an application of barnyard manure and was plowed and thoroughly fitted for strawberries. Ten plants of each of the varieties tested were set May 16 and 17 in rows three and one-half feet apart. The plants were two feet apart in the row. During the season they were cultivated and hoed as occasion required. The blossom clusters were kept picked off, but no runners were removed. This was for the purpose of comparing the different varieties with regard to the number of runners produced. As the runners spread into the space between the rows the cultivator was narrowed to avoid breaking them. About the middle of July an application of acid phosphate at the rate of 825 pounds per acre was broadcasted over the rows and during the last half of September an application of wood ashes was given at the rate of 780 pounds per acre.

Early in December, when the ground was frozen, the bed was covered to a depth of three or four inches with clean wheat straw. On the approach of warm weather the following spring, the covering was shaken up and a portion removed from directly over

Plate XLI.—Strawberry Blossoms: 1, Injured by Frost; 2, Uninjured.

the plants and placed between the rows. In about three weeks the straw remaining over the rows was again shaken up and part of it was removed to prevent smothering the plants, leaving enough, however, to keep the berries clean at fruiting time. During the spring the beds were weeded twice.

The plants came through the winter in excellent condition and gave promise of a full crop. Shortly before blooming time, several light frosts or freezes followed each other in rapid succession, seriously injuring some of the varieties and even killing fruit buds protected by two or three inches of straw. Had this not occurred, the yield of some of the varieties would doubtless have been greater. Not only was the injury apparent in the dead and blackened centers after the buds opened, but it could also be seen by an examination of the unopened buds. By cutting into them the discoloration of the injured centers could be seen, showing all gradations of injury. Not only were the pistils dead, but in many cases the injury extended to the stamens, as was indicated by their changing in color to a light brown. The petals however appeared to be uninjured even in the unopened buds. The buds opened as usual and to the casual observer appeared to give promise of a full crop, though in fact no fruit was set. The accompanying illustration shows injured (1) and uninjured blossoms (2).

Just before the blossoms opened all varieties were sprayed thoroughly with Bordeaux mixture. This tended to reduce the amount of leaf blight, commonly called "rust." Some varieties were evidently much more subject to this disease than others, and were more or less injured by it, notwithstanding the treatment.

Before and during the fruiting season there was an abundance of rain, as shown by the following table, which gives the maximum and minimum temperatures and the rainfall for the months of April, May, June and July, 1902. At no time were the plants suffering from lack of moisture. For this reason some varieties doubtless gave greater yields and larger berries than they would have produced in a season of less rainfall.

TABLE I.—RECORD OF TEMPERATURE AND RAINFALL FOR APRIL, MAY, JUNE AND JULY, 1902.

Date.	April.			May.			June.			July.		
	Max	Min.	Rain-fall.	Max.	Min.	Rain-fall.	Max.	Min.	Rain-fall.	Max.	Min.	Rain-fall.
	Deg.	Deg.	Ins.	Deg.	Deg.	Ins.	Deg.	Deg.	Ins.	Deg.	Deg.	Ins.
1...	40	29	.08	54	41	.02	82	56.5		76	53	
2...	40	32		61	34		82	63	.02	77	55	.41
3...	36.5	31	Trace	62	52		85	62	.28	75	61	
4...	42	30		70	49	Trace	76.5	59		83.5	62	.62
5...	51	25		66.5	55	Trace	66	48		83	63	.75
6...	56	29	.03	69	40	.77	80	38		84	66.5	.05
7...	48	33		——	54		78	62	.42	86	65	
8...	45.5	37	.92	71	43		73	51.5	.08	88.5	65	
9...	45.5	38	.26	67	34		70.5	42		88.5	63	.51
10...	42	35	.03	45	27		68	55	.08	80	63	Trace
11...	54	37	.15	58	26		67	41.5		80	55	
12...	49	35	.05	64	32	.08	75	57	.08	80	55	
13...	46	36	Trace	59	43.5		77	58	.02	85	55.5	
14...	46	34		58	31		81	57	.61	90	62	
15...	55	32.5		59	37.5		83	65	.05	87	——	
16...	57	30	.02	72.5	36		79	62	.09	78	58	.05
17...	57	39		72	45		68	50		86	56	.15
18...	64	34		77	45	.38	79	50.5		82	63	.81
19...	63	43	Trace	77.5	56	.09	79	59	.06	71.5	60	.34
20...	62	45		72	52	.03	75	51	.63	67	62	.68
21...	63	40	Trace	73	36		69	54	.05	78	60	
22...	87	48		90	49	.05	67	47	.03	74	59	
23...	83	53		87	65	.15	64	44	.02	84	54	.33
24...	58	32		81	62.5	.10	70	47	.14	79.5	60.5	.30
25...	53	28	.05	79	57	.83	74	45	.42	79	55	
26...	73	45	.03	73	57	.15	68	53	Trace	82	62	
27...	65	39	Trace	67	45	Trace	68	51		90	66	.05
28...	70	36		47	35	.09	74	53	.06	85	68	.20
29...	67	44	.30	64	35		68	54	.71	83.5	65	Trace
30...	72.5	52		64	52	Trace	62	47	.48	85	65	Trace
31...				79	45					85.5	67	Trace

YIELDS AND VARIETIES.

The following table gives for each variety under test the date of coming into bloom, date of first and last pickings and total yield in ounces. As indicated in this table, the yield varied from 422 ounces with the most productive variety, to 44 ounces with the least productive variety. While with many varieties the yield was greatly reduced through frost injury to the blossoms, with others there was an abundant crop in spite of the late freezes. The wide range in productiveness shown by the different varieties in this test is a good example of the great difference in varieties in their ability to withstand unfavorable conditions.

TABLE II.—SEASON AND YIELD OF STRAWBERRY VARIETIES.

VARIETY.	Date of coming in bloom.	Date of first picking.	Date of last picking.	Yield of 20-ft. row.
				Ounces.
Crescent	May 21	June 18	July 17	422
Riehl No. 29	21	18	17	419
Monitor	24	21	17	394
Manokin	21	21	17	366
Beder Wood	21	18	17	350
Howard No. 2	21	21	17	333
Riehl No. 26	24	18	14	308
Kansas	24	21	14	292
Rough Rider	30	21	17	283
Henry	21	21	10	266
Brandywine	21	24	17	265
Sample	24	24	10	259
Wm. Belt	24	24	17	237
Nedmac No. 1	21	18	10	229
Salem	21	21	14	223
Bennett	24	21	14	219
Miller	26	21	14	218
Riehl No. 32	24	21	17	213
Riehl No. 31	24	24	14	206
Nettie	26	27	17	205
Stella	26	24	14	204
Riehl No. 27	21	21	10	201
Howard	24	21	10	200
Mrs. Fisher	30	27	17	188
Glenwood	21	18	17	188
Carrie Silvers	24	18	10	187
Joe	24	24	17	187
Minute man	21	18	17	182
Hazel	21	21	14	173
Prof. Fisher	24	24	17	171
Riehl No. 25	24	24	7	170
Ham	24	24	10	164
Hunt No. 1	24	24	17	164
Lehman No. 1	19	24	14	163
Corsican	21	24	10	159
Babcock No. 4	21	21	14	155
Jessie	21	24	10	153
Almond	24	21	10	150
Sampson	21	24	14	148
Jim	21	21	14	145
Elma	21	24	17	144
Auto	19	21	7	137
Robbie	30	24	17	133
Johnson Late	30	July 7	17	129
Nina	24	June 21	14	115
Marshall	21	24	17	111
Riehl No. 30	21	18	10	111
Armstrong Favorite	24	24	10	110
Riehl No. 28	21	21	14	110
Belmont Seedling	21	18	10	108
Maximus	21	24	10	101
Sharpless	21	24	17	97
Leon	24	24	10	96
New York	24	24	7	53
Reba	24	27	10	53
Oliver	21	21	7	44

None of the very early varieties were included in this test. Among those which were tested were some which may be called medium early. These are named in the following list:

Beder Wood,	Minute Man,
Belmont Seedling,	*Nedmac No. 1,*
Carrie Silvers,	*Riehl No. 26,*
Crescent,	*Riehl No. 29,*
Glenwood.	*Riehl No. 30.*

Of these varieties, *Belmont Seedling* and *Nedmac No. 1* are not considered worthy of further trial. Beder Wood and Crescent are well known. Glenwood is attractive in color and good in quality, but the foliage blights considerably. *Riehl No. 29* and *Riehl No. 30* not only lack in uniformity of size and shape but their color is not attractive. Carrie Silvers, Minute Man and *Riehl No. 26* maintained their size throughout the season. They ranked good in quality.

Owing to the cool, wet weather, the picking season was somewhat later than usual. Some of the varieties gave excellent yields up to the last picking. Those which ripened the bulk of their crop during the latter half of the fruiting season may be considered as late varieties. These are:

Brandywine,	Nettie,
Elma,	Prof. Fisher,
Johnson Late,	Robbie,
Mrs. Fisher,	Rough Rider,

With some varieties the picking season was considerably longer than with others. Among those ripening throughout a long period are:

Beder Wood,	Monitor,
Crescent,	*Riehl No. 26,*
Glenwood,	*Riehl No. 29,*
Howard No. 2,	*Riehl No. 32,*
Manokin,	Rough Rider.
Minute Man,	

DESCRIPTION OF VARIETIES.

In the following notes the pistillate or imperfect varieties are indicated by the letters Imp., and staminate or perfect flowering varieties by the letters Per., following the name. Unnamed varieties are printed in italics. An italicized statement of the source of the plants follows each name.

Armstrong Favorite, Per. *From Station beds.* Medium to very large, irregular wedge-shaped, light to dark scarlet, nearly soft. Not equal to standard varieties.

Almond, Per. *From J. H. Black, Son & Co., Hightstown, N. J.* Medium, roundish, scarlet. Holds its size well in later pickings.

Auto, Per. *From Slaymaker & Son, Dover, Del.* Medium to very large, conical, sometimes necked; attractive scarlet when fully ripe; flesh rather pale scarlet, rather firm, moderately juicy, mild, fair to good. Vigorous, moderately productive, runners abundant. Holds its size fairly well in late pickings. Lack of uniformity in size and shape are undesirable features. Many blossoms were killed by frost.

Babcock No. 4, Per. *From Station beds.* Medium to large, conical, light scarlet; flesh light colored, good. Vigorous, moderately productive. Fruit averages medium size in late pickings.

Beder Wood, Per. *From Birdseye & Son, Stanley, N. Y.* Above medium, dropping to below medium as the ripening season advances, conical, light scarlet. This well-known variety is not equal in color or quality to some of the standard varieties, but is usually more productive, and is rather early.

Belmont Seedling, Imp. *From W. O. Walrath, Lycoming, N. Y.* Small to medium, unattractive dull scarlet, poor. Seeds in deep pits. No better than a wilding.

Bennett, Imp. *From M. Crawford, Cuyahoga Falls, O.* Above or below medium according to advance of ripening season, wedge-shaped, rather dark, attractive scarlet, moderately firm, nearly sweet, juicy, good. Productive. Vigorous, runners moderately numerous.

Brandywine, Per. *From Station beds.* This well-known variety is not so uniform in shape and does not average so large in size here as in many other localities.

Carrie Silvers, Imp. *From J. H. Black, Son & Co., Hightstown, N. J.* Medium to very large, quite irregular, attractive scarlet; flesh good scarlet, good. It retains its size well in later pickings and becomes more uniform in shape.

Corsican, Per. *From Green's Nursery Co., Rochester, N. Y.* Large, irregular, light to dark crimson, not juicy; calyx often dull green, detracting from appearance. As fruited this season it is not a promising variety.

Crescent, Imp. *From Birdseye & Son, Stanley, N. Y.* This variety is too well known to need comment. It was the most productive and one of the earliest sorts in our collection this season.

Elma, Imp. *From J. H. Black, Son & Co., Hightstown, N. J.* Above medium, wedge-shaped, rather dull, unattractive scarlet; seeds deeply set; flesh rather light-colored at center. Not a promising variety.

Glenwood, Per. *From Station beds.* Above medium, irregularly wedge-shaped; attractive, glossy dark scarlet; flesh dark scarlet, moderately firm, sweet, good. Fairly productive. Probably not firm enough to be a good shipper.

Ham, Per. *From J. H. Black, Son & Co., Hightstown, N. J.* Large, decidedly wedge-shaped, very dark crimson, firm. Seeds quite prominent. Holds size well in late pickings. Too dark in color for some markets.

Hazel, Imp. *From J. H. Black, Son & Co., Hightstown, N. J.* Above medium, decreasing in size later in ripening season, variable in shape, almost too light a scarlet, rather soft, good.

Henry, Per. *From J. O. Wadsworth, Walcott, N. Y.* A chance seedling known locally as "Henry." This is not the variety already quite widely known under this name. Medium to large, roundish, rather dark attractive scarlet; flesh deep crimson, nearly firm, juicy, good to very good. Vigorous, productive. Runners abundant. Decreases in size in later pickings. Worthy of testing when large size is not a primary consideration.

Howard, Per. *From J. H. Black, Son & Co., Hightstown, N. J.* Medium to large, conical, rather light scarlet, firm, good. Irregular in development of apex, thus often making the fruit appear seedy. Vigorous, productive, runners abundant.

Howard No. 2, Imp. *From G. W. Howard, Stevensville, Mich.* Large to very large, conical, attractive light scarlet. Very productive, but cannot be recommended because it lacks in quality and firmness.

Hunt No. 1, Per. *From Station beds.* Irregular, light scarlet. The color of the fruit is too pale and the foliage too weak to make this a promising variety.

Jessie, Per. *From Birdseye & Son, Stanley, N. Y.* Large to very large, light to dark scarlet, fine aroma. With us this variety is only moderately productive, but does much better on some other soils.

Jim, Imp. *From J. H. Black, Son & Co., Hightstown, N. J.* Medium to large, wedge-shaped, rather light scarlet, rather soft, good.

Joe, Per. *From J. H. Black, Son & Co., Hightstown, N. J.* Large to very large, irregularly wedge-shaped, attractive dark scarlet, moderately firm and juicy, good. Vigorous, remarkably free from leaf-blight, moderately productive. Runners moderately numerous. Ranks high in size.

Johnson Late, Imp. *From Station beds.* Large, conical, very light scarlet, soft; flesh almost white, good. Not very productive. During all the years in which Johnson Late has been grown at this Station it has always been the latest variety in the collection to ripen its fruit.

Kansas, Imp. *From W. F. Allen, Salisbury, Md.* Medium to very large, wedge-shaped and in early pickings roughly furrowed, attractive dark scarlet, firm, juicy, good. Vigorous, remarkably free from leaf-blight, quite productive, runners numerous. The fruit retains its size throughout the season and at the same time gains in uniformity of shape.

Lehman No. 1, Per. *From Station beds.* Medium to large, wedge-shaped, scarlet, firm, good. Seeds rather prominent and noticeably yellow. Size and shape lack uniformity. Not equal to some of the best varieties.

Leon, Imp. *From J. H. Black, Son & Co., Hightstown, N. J.* Above medium to large, oval, light scarlet, rather poor quality. A poor producer. Not a promising variety.

Manokin, Imp. *From Slaymaker & Son, Dover, Del.* Medium to large, wedge-shaped, light scarlet, soft, juicy, fair. Vigorous, very productive. The fruit is easily bruised and does not retain its size in later pickings.

Marshall, Per. *From Ellwanger & Barry, Rochester, N. Y.* This is one of the best varieties but does not succeed in all soils. It ranks low in productiveness this year on account of having been severely injured by frost. It is worthy of a trial where it has not already been tested.

Maximus, Per. *From Station beds.* Below medium to large, often furrowed, light to dull dark scarlet, firm. Blossoms were severely injured by frost. Not a promising variety.

Miller, Per. *From M. Crawford, Cuyahoga Falls, O.* Medium to large, conical, attractive light scarlet, flesh nearly white, soft, fair to good. Vigorous, productive. Foliage considerably blighted.

Minute Man, Imp. *From Geo. F. Wheeler, Concord, Mass.* Above medium to large, wedge-shaped to conical, attractive light scarlet, soft, good. Retains its size well in later pickings.

Monitor, Per. *From Z. T. Russell, Carthage, Mo.* Above medium to large, wedge-shaped, pale scarlet; flesh whitish at center, firm, juicy, fair to good. Very productive. Runners very numerous. The fruit retains its size in later pickings and is remarkably uniform in size and shape. For local markets where firmness and quality are not prime requisites, this variety appears desirable.

Mrs. Fisher, Imp. *From J. H. Black, Son & Co., Hightstown, N. J.* Large to very large, decidedly wedge-shaped, attractive light scarlet. The size is unusually good for a light berry. Moderately productive.

Nedmac No. 1, Imp. *From T. M. Chambers, Camden, N. Y.* Small to medium, roundish, scarlet, firm, good. Productive. As fruited here the berries are too small to be valuable as a commercial variety.

Nettie, Imp. *From J. H. Black, Son & Co., Hightstown, N. J.* Above medium to very large, wedge-shaped or oval, sometimes hollow at the center, rather light scarlet, nearly firm; flesh good color, juicy, good. Vigorous, productive. This is one of the largest of the late varieties.

New York, Per. *From W. F. Allen, Salisbury, Md.* Below medium to large, wedge-shaped, light to dark scarlet. Very unproductive. The fruiting period was short this year.

Nina, Per. *From J. H. Black, Son & Co., Hightstown, N. J.* Medium to large, irregular, attractive scarlet. Not productive; severely injured by leaf blight. The hull has a tendency to pull off easily and on this account the fruit would not keep well.

Oliver, Per. *From J. H. Black, Son & Co., Hightstown, N. J.* Varies from small to large, berries with hard green tips, conical, dark scarlet, very unproductive. Blossoms were seriously injured by frost.

Prof. Fisher, Per. *From J. H. Black, Son & Co., Hightstown, N. J.* Above medium to very large, usually wedge-shaped but not uniform, attractive scarlet, flesh good color, good. Retains its size as the ripening season advances. Vigorous, moderately productive; runners very few. On account of this last fact this variety should be planted closer than most others.

Reba, Imp. *From J. H. Black, Son & Co., Hightstown, N. J.* Above medium to large, bluntly wedge-shaped, attractive scarlet. Very unproductive and too soft to ship far.

Riehl No. 25, Per. *From Station beds.* Large, wedge-shaped, dark scarlet, good. Moderately productive. Retains size well in later pickings. The color is rather too dull and dark to be attractive.

Riehl No. 26, Per. *From Station beds.* Medium to large, irregularly heart-shaped, crimson, rather firm, moderately juicy, subacid, good. Vigorous, very productive, runners numerous. Retains its size as the ripening season advances and is attractive in appearance. Promising.

Riehl No. 27, Per. *From Station beds.* Medium to very large, roundish, usually very dark and often dull scarlet, soft, good. Productive. Does not retain size in later pickings.

Riehl No. 28, Per. *From Station beds.* Above medium to very large, irregularly conical, attractive scarlet, flesh good scarlet, moderately firm. Moderately vigorous. Not very productive this season but desirable in size, shape and color. It retains its size in later pickings.

Riehl No. 29, Per. *From Station beds.* Medium to large, irregular, with the berries often divided by deep furrows into two or three segments, light scarlet, moderately firm, subacid, good. With one exception the most productive variety tested this season. Foliage light green, moderately vigorous. Runners numerous. While some specimens of fruit have good color many are too light to present an attractive appearance. Does not retain its size in later pickings.

Riehl No. 30, Per. *From Station beds.* Medium to large, conical, rather dull scarlet, moderately firm, good. Not productive this season, partly at least because many blossoms were killed by frost. Fruits are irregular in size and the color is not very attractive.

Riehl No. 31, Per. *From Station beds.* Large, conical, attractive dark scarlet, firm, very good. Productive. Vigorous; runners moderately numerous. One of the best in quality of Riehl's seedlings. Retains its size in later pickings. Worthy of trial where a dark berry is desirable.

Riehl No. 32, Per. *From Station beds.* Medium to very large, conical or irregular, good glossy scarlet, moderately firm, sweet, juicy, good. Moderately vigorous, not very healthy, productive. Some berries show a tendency to green tips.

Robbie, Per. *From J. H. Black, Son & Co., Hightstown, N. J.* Above medium to large, conical or wedge-shaped, with a tendency to green tips, rather light scarlet, flesh pale scarlet, firm. Not productive. A late variety.

Rough Rider, Per. *From L. J. Farmer, Pulaski, N. Y.* Above medium, conical, bright attractive scarlet, firm, fair to good. Quite productive. Foliage vigorous. Runners moderately numerous. Appears promising as a late berry. Fruit is symmetrical and retains its size during the season.

Salem, Per. *From B. M. Smith, Beverly, Mass.* Below medium to large, irregular, rough, attractive deep scarlet, soft. Foliage not vigorous, pale green, low, exposing fruit considerably to the sun. Productive. Not equal to standard varieties.

Sample, Imp. *From C. S. Pratt, Reading, Mass.* Above medium to large, conical, attractive bright scarlet, moderately firm, fair.

Moderately vigorous, considerably injured by leaf-blight, productive. Runners moderately numerous. Retains size in later pickings. This variety is highly recommended in some localities on account of productiveness, attractive size and color and length of ripening period.

Sampson, Per. *From M. Crawford, Cuyahoga Falls, O.* Medium to very large, irregular, sometimes necked, rather unattractive light scarlet, flesh, light in color. Not equal to standard varieties.

Sharpless, Per. *From Birdseye & Son, Stanley, N. Y.* This well-known variety does not do so well in this locality as in many others.

Stella, Imp. *From J. H. Black, Son & Co., Hightstown, N. J.* Above medium to very large, mostly wedge-shaped, attractive scarlet, soft, fair. Retains size in later pickings. A large berry, but lacks in firmness and quality.

Wm. Belt, Per. *From M. Crawford, Cuyahoga Falls, O.* Very large, wedge-shaped, firm. Vigorous and productive, but severely attacked by leaf-blight. Does not do so well here as in many other localities.

INVESTIGATIONS CONCERNING THE SELF-FERTILITY OF THE GRAPE, 1900-1902.*

S. A. BEACH.

SUMMARY.

I. POTENCY OF POLLEN OF SELF-STERILE GRAPES.

In previous experiments varieties of grapes which are self-sterile or nearly so have shown about as little ability to fertilize other self-sterile sorts as they have for fertilizing themselves. In the tests here reported they have usually likewise failed to fertilize self-fertile varieties. Indications are seen, however, that the pollen in some instances is not altogether impotent but that its own pistils are less congenital than those of some other varieties. Further investigation is needed to learn whether or not this self-sterility arises because the pollen is deficient in amount, or is not well developed, or is uncongenial to its own variety.

II. INFLUENCE ON SELF-FERTILITY OF GIRDLING OR BENDING THE FRUITING CANES BEFORE THE BLOOMING SEASON.

Girdling or bending sharply the fruiting canes of imperfectly self-fertile or self-sterile grapes before their blossoms open in some cases has stimulated them to increased productiveness. In other cases it has not.

Further tests are needed to learn whether such practice may under any circumstances be profitably followed with any American varieties in commercial vineyards.

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* A reprint of Bulletin No. 223.

INTRODUCTION.

Many kinds of cultivated grapes have been found to be more or less self-sterile. They either utterly fail to fruit or produce imperfect clusters when the vines are planted by themselves; but they may fruit abundantly when grown near enough to other varieties to secure cross-pollination. This is demonstrated in previously reported investigations which are summarized in Bulletin No. 157.[1] From other experiments it appears that the degree of self-fertility of a variety is a very good indication of its efficiency in fertilizing self-sterile kinds of grapes. So far as they have been tried, the self-sterile kinds are usually no more capable of fertilizing other self-sterile kinds than they are of setting fruit themselves, but when pollen of strongly self-fertile kinds has been used on the self-sterile grapes an abundance of perfect fruit has generally developed. In such cases it is evident that the lack of fertility cannot be attributed to imperfection of the pistils. If these were imperfect no fruit would develop from them under any circumstances. The experiments just referred to are fully set forth in Bulletin No. 169.[2] Observations made in 1892 and in various succeeding years show that self-sterile varieties do produce pollen.[3] The question then arises: Is such pollen altogether impotent? Is it as incapable of causing the fertilization of self-fertile as it is of self-sterile grapes? The experiments reported on the following pages were undertaken to get more information on this subject. The work was carried on with the efficient help of Mr. Heinrich Hasselbring and Mr. O. M. Taylor in 1901. Mr. Taylor also assisted in the work of 1902. At the same time the influence on self-fertility of checking the flow of sap, either by girdling or by twisting and bending the cane between the trunk of the vine and the fruit buds, was investigated. The report of this work is given in Part II of this bulletin.

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[1]Reprinted in Annual Report of this Station for 1898: 518–563.

[2]Reprinted in Annual Report of this Station for 1899: 361–397.

[3]Notes on Self-Pollination of the Grape. Proc. A.A.A.S. 1892. *Gard. ana For.*, 1892: 451–452. Annual Reports of this Station 1892: 597–606, and 1894: 642-643; also other unpublished observations.

In addition to these experiments a study of grape pollen was carried on in the laboratory in 1902, by Professor N. O. Booth. The results will appear in Bulletin No. 224.

I. POTENCY OF THE POLLEN OF SELF-STERILE GRAPES.

LOCATION OF EXPERIMENTS.

Most of the tests here reported were carried on in the vineyard of Mr. E. C. Gillett, Penn Yan, N. Y. It is a pleasure to acknowledge Mr. Gillett's uniform courtesy and cordial co-operation in this work. A few of the tests were made on vines in the Experiment Station vineyards.

METHODS OF WORK.

In all cases the vines selected for the tests were apparently in good productive condition. They were similarly treated so far as spraying to prevent the attacks of fungous diseases was concerned; they were also similarly pruned, trained and cultivated. The plan which was followed was to castrate certain self-fertile varieties before their blossoms opened, and then to apply to them the pollen taken from certain self-sterile or imperfectly self-fertile sorts. In order to prevent the access of other pollen than that desired, the clusters to be pollinated were covered with manilla paper bags[1] as soon as they were castrated, and thereafter kept thus covered except during the operation of cross-pollinating them. The clusters selected to supply the pollen for the experiment were likewise bagged before blooming to prevent admixture of foreign pollen. They were kept in these bags till used.

Castration.— The methods of operating in castrating the buds were varied according to the condition of the buds when the work was performed. When the operation is delayed till the buds are opening or about to open there is danger that some stigmas may accidentally become self-pollinated during the

[1]The bagging was done according to the method shown in Bulletin No. 157:401; also in Annual Report of this Station for 1898:521.

process of castration. It was, doubtless, under such conditions that the self-pollinations occurred which resulted in the development of the few fruits mentioned in the list of check castrations. See Table I. But if, on the other hand, the buds are castrated too early they may fail to develop further and die before fertilization is accomplished.

In some cases the cap and anthers were removed by means either of pliers or scapel. This method is well adopted to meet the conditions for successful operation when buds are about to open. In most cases, however, the operation was performed at an earlier stage in the development of the bud, and the cap and anthers were removed by pinching them between thumb and finger. By this method the work could be done more rapidly than by the use of tools. If the bud can be operated on at the most favorable stage in its development, usually the cap, with anthers inclosed, may be readily pulled off with one movement of thumb and finger without either injuring the pistil or self-pollinating it. In doing this the end of the cap is pinched either between finger and thumb or between finger and thumb-nail. As a check upon this method of castration, many clusters after being thus operated upon were immediately inclosed in paper bags without being cross-pollinated, and were kept covered till the blooming season had passed. Any fruit which developed on these clusters must have resulted from accidental self-pollination during the operation of castrating the blossom buds. The following is a list of the check castrations referred to with a statement of the number of fruits produced.

TABLE I.— CHECK CASTRATIONS.

NAME OF VINE.	Number of clusters castrated.	Number of fruits developed.	Average fruits per cluster.
Gillett red seedling	4	20	5.
Beacon	8	0	0.56
Beacon	1	5	
Catawba	1	0	0.
Concord	19	0	0.15
Concord	1	3	
Diamond	15	0	0.375
Diamond	1	6	
Hartford	1	0	0.
Niagara	13	0	0.
Pocklington	6	0	0.
Worden	12	8	
Worden	4	8	0.5
Total	86	42	....

Taking all clusters into account, the average number of fruits produced per cluster was 0.49. Estimating the number of castrated blossoms per cluster at 50, it appears that less than 1 per ct. of the castrated blossoms developed into fruit. The method of castrating the grape with thumb and finger, if used with care, is well adapted for an experiment like the one under consideration. In this case so many blossoms were included in the tests that the general results may be accepted as giving a reliable indication of the potency of the pollen tested. In considering the results of the experiments, the fact should not be lost sight of that nearly 1 per ct. of the check castrations developed fruit from accidental self-pollination.

After castration the clusters were immediately inclosed in paper bags, which were closed with a wired label. This covering was not removed again till the operation of cross-pollination was undertaken.

Pollination.—When the varieties which had been chosen to furnish the supply of pollen came into bloom the covered clusters were cut off and, without removing them from the bag, were taken to the castrated clusters which were to be cross-pollinated. The stigmatic surfaces of the latter were then touched

with the open anthers of the former. The pollen-bearing cluster was also shaken against the castrated blossoms; finally, after being cross-pollinated thus, the cluster was usually covered with the bag which had contained the pollen-bearing cluster. After being closed with a wired label this bag was then shaken so that loose pollen, if it should contain any, might perchance alight upon some stigmatic surface.

In these experiments the operation of cross-pollination was performed but once for each cluster. Whenever at the time of this operation a considerable percentage of the stigmas appeared not to be in good receptive condition note was made of this fact. This sometimes occurred when the pollen-bearing blossoms opened later than those which were to be cross-pollinated from them. When the conditions were reversed, and the blooming season of the pollen-bearing cluster was in advance of that of the variety to be cross-pollinated, the process of cross-pollination was, nevertheless, performed as above described. It is known that grape pollen may retain its vitality for days.

Labeling.— On the label was written the particular number by which the cluster was designated in the experiment records, the name of the variety and the name of the pollen-bearing variety. The name of the mother plant was always written first, followed by x and the name of the variety with which it was cross-pollinated. Thus, "9471 Concord x Lindley" indicated a particular cluster of Concord, which, after being castrated, was cross-pollinated with Lindley pollen.

VARIETIES UNDER EXPERIMENT.

Self-sterile pollen[1] was tried upon the five strongly self-fertile varieties—Concord, Delaware, Diamond, Niagara and Worden—and also upon Vergennes, which is often less strongly self-fertile.[2] The list of varieties selected to furnish pollen for the tests is given below. In previous tests these varieties have

[1]Throughout this discussion "self-sterile pollen" denotes pollen produced by self-sterile varieties; "imperfectly self-fertile pollen" and "self-fertile pollen" have corresponding significance.

[2]The standing of Vergennes, as to self-fertility, is given on pages 370 and 372.

proved very nearly or quite self-sterile. They are Black Eagle, Brighton, Eldorado, Herbert, Lindley, Merrimack and Salem. The results of applying the self-sterile pollen obtained from these varieties to the stigmas of castrated self-fertile kinds are summarized in Table II. For better understanding of the tabulated results, the following facts relative to the degree of self-fertility of certain varieties should be noted.

In most cases Brighton clusters utterly fail to develop fruit except when cross-pollinated. In rare instances self-pollinated clusters have produced a little fruit. The fruit thus produced is generally small and seedless, as illustrated in Bulletin No. 157, Plate III, Fig. 1, and in the Annual Report of the Station for 1898, Plate LI, Fig. 1.

With one exception, all clusters of Lindley which we have tested for self-fertility have been completely self-sterile. The single exception, consisting of one cluster which bore four berries, falls within the limits of error in testing self-fertility. Lindley, therefore, may be called practically self-sterile, if not absolutely so.

Merrimack pollen was applied to some castrated blossoms of *Gillet red seedling*,[1] while other castrated blossoms of the same kind were not hand pollinated at all. In both cases some fruit was produced, and therefore it is not certain that the Merrimack pollen was potent. See Table I and Table II.

Vergennes must be classed among the imperfectly self-fertile varieties, but yet it is sufficiently self-fertile to sometimes produce marketable clusters when self-pollinated only. In many cases, however, its clusters of self-fertilized fruit are too loose and unsymmetrical to be marketable. The influence of the condition of the vine, location of the vineyard and character of the season on the development of the self-pollinated clusters is not well understood; but it has been observed that in the same vineyards in some seasons the self-pollinated Vergennes clusters have been better developed than in others; also in the same season better self-pollinated clusters have been obtained in one vineyard than in others.

[1]The *Gillett red seedling* is an unnamed seedling growing in Mr. Gillett's vineyard.

In the table all varieties in the column headed "Variety cross-pollinated" were castrated, except in those cases where self-sterile kinds had pollen of the same varieties used upon them. The rank of the various varieties as to self-fertility is either explained in the notes just given or is indicated in the table, under "Remarks."

TABLE II.— RESULTS OF CROSS-POLLINATING SELF-FERTILE GRAPES WITH POLLEN OF EITHER SELF-STERILE OR IMPERFECTLY SELF-FERTILE VARIETIES.

Variety cross-pollinated.	Variety furnishing pollen.	Number of clusters cross-pollinated.	Number of pistils cross-pollinated.	Number of Fruits Developed. Normal size.	Small and seedless.	Total.	Average per cluster.	Remarks.
Black Eagle...	Black Eagle..	7	......	0	0	0	0	
Bailey........	Black Eagle..	......	......	......	......	......	......	See page 370 and table III.
Delaware......	Black Eagle..	5	227	0	0	0	0	
Brighton[1].....	Brighton.....	10	......	0	0	0	0	Brighton is almost self-sterile.
Delaware......	Brighton.....	5	134	0	0	0	0	
Niagara.......	Brighton.....	2	85	0	0	0	0	
Eldorado[1].....	Eldorado....	5	......	0	0	0	0	
Brighton[2].....	Eldorado....	5	......	0	0	0	0	Brighton is almost self-steriie.
Delaware......	Eldorado....	4	153	0	0	0	0	
Herbert[1]......	Herbert......	11	......	0	0	0	0	
Concord.......	Herbert......	4	219	0	0	0	0	
Niagara.......	Herbert......	5	213	0	0	0	0	Two Herbert clusters had shed the pollen before the Niagara was cross-pollinated; the other 3 clusters had freshly opened anthers.
Vergennes[4]....	Herbert......	4	......	12	17	29	3[3]	Each cluster developed a few berries, some small and seedless, others of normal size.
Worden.......	Herbert......	1	191	0	0	0	0	Average for 5 clusters, 3.8.
		4		19	0	19	4¾	
Lindley[1]......	Lindley......	9	......	0	0	0	0	Lindley is nearly or quite self-sterile.
Concord... ...	Lindley......	5	251	0	0	0	0	
Niagara.......	Lindley......	5	259	2	0	2	.....	Two fruits on one cluster.

Worden	Lindley	5	159	20	0	20	4	From 2 to 8 fruits to each cluster. Castration probably delayed too long, so that fruits may be due to action of Worden pollen. Compare with results of Worden x Herbert above; and with Worden castrated but not cross-pollinated in table I.
Merrimack[1]	Merrimack	9	......	0	0	0	0	
Concord	Merrimack	5	281	4	0	4	......	One cluster bore 4 small berries each containing one seed.
Gillett red seedling.	Merrimack	4	147	36	0	36	9	This seedling is to some degree self-fertile; rank not definitely determined. These fruits probably resulted from accidental self-pollination of *Gillett red*. See page 368.
Niagara	Merrimack	5	277	3	0	3	......	Three fruits on one cluster.
Worden	Merrimack	1	19	0	0	0	0	
Salem[1]	Salem	15	......	0	0	0	0	
Concord	Salem	4	240	5	0	5	......	Five fruits on one cluster.
Diamond	Salem	1	27	2	0	2	2	
Herbert[2]	Salem	5	......	0	0	0	0	
Niagara	Salem	5	328	2	0	2	......	Fruits on one cluster.
Vergennes[4]	Vergennes	{ 14 / 4 }	......	......	......	......	......	In 1901, 14 self-pollinated clusters developed clusters of fruit; 6 symmetrical and compact; 2 only moderately compact yet marketable; 6 too loose for market. In 1902, 4 self-pollinated clusters were tested, giving no marketable bunches. Fruit clusters about like last described in 1901.
Concord	Vergennes	{ 1 / 1 }	25 / 42	0 / 4	0 / 0	0 / 4	{ 0 / 4 }	In view of the following results with Diamond and Niagara these tests should be verified.
Diamond	Vergennes	3	102	38	0	38	127	
Niagara	Vergennes	5	270	125	0	125	25	Both pollen and pistils appeared to be further advanced than desirable when the cross-pollination was made.

[1] Not self-fertile; pollen from other plants of same variety applied to uncastrated flowers as a check. [2] Flowers not castrated. [3] Average of normal berries. [4] More or less imperfectly self-fertile.

In addition to the tests above described a few others were made, using more careful methods to insure both perfect castration without either injury to the pistil or self-pollination of it, and also an abundant application of the pollen used in cross-pollination. On June 28 unopened buds of Black Eagle were covered with manilla bags to prevent the access of foreign pollen. On June 29 they had begun to open. The whole cluster, without being removed from the bag, was cut from the vine and taken to the laboratory, where the anthers were removed, put into a wide, short test tube and shaken till the bottom of the tube was well covered with pollen. A cluster of Bailey, in which the buds were nearly ready to open, was then selected. Part of the buds were cut out and the rest, 24 in number, were very carefully castrated by means of pliers and scalpel. Both the tools and the fingers were repeatedly dipped into strong alcohol during the operation, to prevent accidental self-pollination. Any bud in which any dehiscence of the anther appeared was at once discarded. After castration the cluster was pushed into the tube as far as the tube would contain it and the naked stigmas brushed against the sides and bottom, which were covered with the Black Eagle pollen. Additional pollen was then applied to each pistil by means of a camel's-hair brush. Finally the cluster was inclosed in a manilla paper bag to prevent the access of other pollen. In a corresponding way other crosses were made. The name of the parents and the number of pistils treated are shown in the following list:

TABLE III.— STRONGLY SELF-FERTILE VARIETIES CROSS-POLLINATED WITH VARIETIES NEARLY OR QUITE SELF-STERILE. SECOND METHOD.

Variety Castrated and Cross-pollinated.		Variety Furnishing Pollen.		Number of clusters cross-pollinated.	Number of pistils cross-pollinated.	No. of Fruits Developed.		
Name.	Class.	Name.	Class.			Normal size.	Small and seedless.	Total.
Hopkins .	Strongly self-fertile.	Ozark.........	Nearly self-sterile.....	2	92	34	....	34
Hopkins .	Strongly self-fertile.	Hexamer......	Self-sterile...	2	49	15	2	17
Bailey...	Strongly self-fertile.	Black Eagle...	Self-sterile...	1	24	1	....	1

The fruits which developed to normal size were supplied with a little less than the usual number of seeds. One hundred Hopkins fruits from clusters open to cross-pollination averaged 4.05 seeds per berry; those of Hopkins x Ozark averaged 3.01, and Hopkins x Hexamer 3.03 seeds per berry. The single fruit of Bailey x Black Eagle had 3 seeds.

In order that the results of the tests which are shown on the preceding pages may be compared with those obtained in using the pollen of self-fertile varieties upon other self-sterile varieties, the following table of Bulletin No. 169 is reprinted here. The data given in that bulletin are here arranged with reference to the ability of each variety to fertilize itself as compared with its ability to fertilize the various self-sterile sorts upon which it was tried.

Explanation of table.— The x between two names indicates that the variety following the x was used in pollinating the variety whose name appears before the x. Thus, Brighton x Aminia indicates that the Brighton clusters were pollinated with Aminia pollen in the manner described on page 335 of Bulletin No. 169. The rating is on the scale of 100 points, as there explained, a perfectly formed and perfectly filled cluster ranking 100. The average rating and the number of tested clusters upon

which the average is based are also stated. The highest rating which any single cluster in the test received is also given.

"Self-pollinated" indicates that the tested clusters were simply kept covered in paper bags during the blooming season. Sometimes the self-pollination was performed by hand, pollen from another vine of the same kind being applied in the manner described in footnote 2, page 340, of Bulletin 169. Such tests are marked "hand-pollinated" in the table.

TABLE IV.— COMPARATIVE FRUITAGE WITH DIFFERENT VARIETIES OF GRAPE TRIED AS FERTILIZERS FOR SELF-STERILE SORTS.

VARIETIES TESTED.	Clusters tested.	Highest rating.	Average rating.
AMINIA as fertilizer:			
self-pollinated	2	0	0.
self-pollinated	9	0	0.
self-pollinated	6	0	0.
self-pollinated	10	12	1.2
Brighton x Aminia	7	2	0.3
Wyoming x Aminia	4	8	2.
BLACK EAGLE as fertilizer:			
self-pollinated	2	20	0.
self-pollinated	10	0	0.
Barry x Black Eagle	5	0	0.
Eumelan x Black Eagle	2	0	0.
BBIGHTON as fertilizer:			
self-pollinated	9	0	0.
self-pollinated	5	0	0.
self-pollinated	27	0	0.
self-pollinated	9	0	0.
self-pollinated	28	4	0.2
self-pollinated	25	10	0.4
self-pollinated[1]	5	4	0.8
self-pollinated[1]	10	15	2.1
self-pollinated	5	10	6.0
Black Eagle x Brighton	4	0	0.0
Eldorado x Brighton	5	0	0.0
Herbert x Brighton	1	0	0.0
Salem x Brighton	3	0	0.0
Aminia x Brighton	6	10	1.7
Lindley x Brighton	3	12	4.0
Merrimack x Brighton	4	35	8.8
Wyoming x Brighton	6	50	12.0
Hercules x Brighton[2]	2	?	?
CATAWBA as fertilizer:			
self-pollinated	12	[3]	[3]
self-pollinated	16	100	81.9
self-pollinated	22	90	85.0
self-pollinated	37	100	89.9
self-pollinated	24	98	85.5
self-pollinated	17	95	86.1
Eldorado x Catawba	4	2	0.5
Salem x Catawba	1	4	4.0
Lindley x Catawba	5	95	63.0
Brighton x Catawba	8	95	74.4
Brighton x Catawba	5	100	80.0
Aminia x Catawba	4	90	89.0
Merrimack x Catawba	3	95	91.7
Herbert x Catawba	2	100	100.
Wyoming x Catawba	1	100	100.

[1]Hand-pollinated.

[2]See Bulletin 169: 349.

[3]The clusters were perfect or nearly so, but were not rated on the scale of 100 points.

TABLE IV —(*Continued*).

VARIETIES TESTED.	Clusters tested.	Highest rating.	Average rating.
COLUMBIAN IMPERIAL as fertilizer:			
self-pollinated	8	100	96.3
Hercules x Colum. Imp.	5	50	36.0
CREVELING as fertilizer:			
self-pollinated	5	0	0.0
self-pollinated	5	0	0.0
self-pollinated	5	0	0.0
Brighton x Creveling	7	0	0.0
EATON as fertilizer:			
self-pollinated	10	0	0.0
self-pollinated	6	100	90.
Hercules x Eaton	5	70	36.0
ELDORADO as fertilizer:			
self-pollinated	5	0	0.0
self-pollinated	10	0	0.0
self-pollinated	23	0	0.0
self-pollinated	4	0	0.0
Herbert x Eldorado	4	0	0.0
Brighton x Eldorado	4	15	5.2
EUMELAN as fertilizer:			
self-pollinated	10	0	0.0
self-pollinated	9	0	0.0
self-pollinated	3	4	1.3
self-pollinated	1	20	20.0
HERBERT as fertilizer:			
self-pollinated	2	0	0.
self-pollinated	5	0	0.
self-pollinated	9	0	0.
Salem x Herbert	5	0	0.
Eldorado x Herbert	5	0	0.
Brighton x Herbert	4	75	28.0
HERCULES as fertilizer:			
self-pollinated	4	0	0.0
self-pollinated	10	0	0.0
self-pollinated	1	[4]	[4]
Barry x Hercules	5	0	0.0
JEFFERSON as fertilizer:			
self-pollinated	3	......	95.0
self-pollinated	4	100	75.0
self-pollinated	7	60	39.3
Brighton x Jefferson	5	100	64.0
LINDLEY as fertilizer:			
self-pollinated	10	0	0.0
self-pollinated	9	0	0.0
self-pollinated	25	0	0.0
self-pollinated	25	40	1.6
Eldorado x Lindley	5	0	0.0
Herbert x Lindley	5	0	0.0
Salem x Lindley	5	2	0.4
Brighton x Lindley	5	10	2.0
Merrimack x Lindley	4	98	32.0

[4]One good cluster well filled, but all fruits seedless.

TABLE IV—(*Continued*).

VARIETIES TESTED.	Clusters tested.	Highest rating.	Average rating.
MERRIMACK as fertilizer:			
self-pollinated	2	0	0.0
self-pollinated	10	0	0.0
self-pollinated	23	0	0.0
self-pollinated	3	0	0.0
Salem x Merrimack	4	0	0.0
Lindley x Merrimack	3	0	0.0
Herbert x Merrimack	5	0	0.0
Brighton x Merrimack	4	100	25.
NECTAR as fertilizer:			
self-pollinated	9	4	......
self-pollinated	2	100	0.9
Brighton x Nectar	5	75	90.0
NIAGARA as fertilizer:			
self-pollinated	10	100	40.0
self-pollinated	23	100	75.7
self-pollinated	12	100	65.8
self-pollinated	16	100	95.1
self-pollinated	20	100	93.3
Aminia x Niagara	1	80	......
Brighton x Niagara	5	100	52.5
Brighton x Niagara	9	88	85.7
Eldorado x Niagara	5	100	76.
Lindley x Niagara	5	95	77.0
Merrimack x Niagara	4	100	96.3
Salem x Niagara	5	100	98.0
Herbert x Niagara	4	100	98.8
ROCHESTER as fertilizer:			
self-pollinated	10	100	100.
self-pollinated	1	100	100.
Brighton x Rochester	5	100	72.0
SALEM as fertilizer:			
self-pollinated	10	0	0.0
self-pollinated	25	0	0.0
self-pollinated	5	0	0.0
Lindley x Salem	5	0	0.0
Herbert x Salem	4	0	0.0
Brighton x Salem	4	0	0.0
Eldorado x Salem	5	2	0.4
Merrimack x Salem	5	4	0.8
STATION 125 as fertilizer:			
self-pollinated	10	100	100.0
Brighton x Station 125	5	100	90.0
STATION 146 as fertilizer:			
Brighton x Station 146	4	60	21.3
STATION 156 as fertilizer:			
Brighton x Station 156	4	100	69.3
VERGENNES as fertilizer:			
self-pollinated	10	.....	....
self-pollinated	22	90	44.5
self-pollinated	5	40	24.0
self-pollinated	8	90	77.5
self-pollinated	9	95	45.6
Brighton x Vergennes	7	100	53.9

TABLE IV—(*Concluded*).

VARIETIES TESTED.	Clusters tested.	Highest rating.	Average rating.
WORDEN as fertilizer:			
self-pollinated	10	....	....
self-pollinated	9	100	100.5
self-pollinated	23	100	96.
self-pollinated	20	100	94.5
self-pollinated	5	90	84.0
self-pollinated	6	100	95.8
self-pollinated	24	100	93.7
self-pollinated	20	100	96.9
Black Eagle x Worden	1	0	0.0
Eldorado x Worden	5	95	65.0
Lindley x Worden	5	100	70.0
Brighton x Worden	4	100	76.0
Brighton x Worden	8	85	77.0
Aminia x Worden	2	88	88.0
Salem x Worden	5	100	89.0
Merrimack x Worden	4	100	97.0
Herbert x Worden	5	100	97.0
WYOMING as fertilizer:			
self-pollinated	10	0	0.0
self-pollinated	4	4	1.0
self-pollinated	13	[5]	[5]
self-pollinated	6	90	21.6
Brighton x Wyoming	6	2	0.3
Aminia x Wyoming	5	20	4.0

The results set forth in Table II show that the pollen of the self-sterile varieties therein named is either deficient in amount or lacking in potency, or both. Table IV bears similar testimony on this point. The results given in Table III show that some varieties which are nearly or quite self-sterile may to some extent fertilize certain other varieties. Occasional indications of this fact are also seen in Tables II and IV. The questions, however, are still not satisfactorily answered as to whether the self-sterility under investigation arises because the pollen is uncongenial to its own pistil, or because it is deficient in amount, or because it is nearly or quite impotent either upon its own or upon other pistils. The last-named condition seems to hold with Black Eagle pollen, because, as shown in Table III, even when it is supplied in abundance it fails to effect the fertilization

[5] But one cluster produced fruit and that was gathered by grape pickers before it had been rated. Its rating was somewhere between 80 and 100, making the average between 6.1 and 7.7.

of the pistil to which it is applied. The one fruit which developed when Black Eagle pollen was tried upon Bailey easily falls within the limits of error for such an operation, and cannot be considered as proof that the fertilization was in fact effected by the Black Eagle pollen. But in the cases where Ozark and Hexamer were tried upon Hopkins, as well as in instances which might be selected from the tests listed in Tables II and IV, it appears that some varieties which, so far as tested, have proved self-sterile are to some extent capable of fertilizing other varieties. This is an indication that their pollen finds its own pistils less congenial than those of certain other varieties. It is hoped that further investigation of these questions may be made.

II. INFLUENCE ON SELF-FERTILITY OF GIRDLING OR BENDING THE FRUITING CANES.

In making the tests reported in Bulletin No. 169, to determine whether some varieties of grapes are better than others for fertilizing self-sterile kinds, two instances were observed in which self-fertility seemed to be increased on canes which had been bent so much as to obstruct the flow of sap. These varieties were normally nearly self-sterile. In tying the vines upon the trellis some fruiting canes had been bent so sharply that the transfer of elaborated food from the part beyond the bend was necessarily checked. It was noticed that a little fruit developed on self-pollinated clusters borne on the distal part of such canes, while none or almost none was borne by corresponding clusters, either on other parts of the same canes or on other canes on the same vine. These observations suggested the question whether in cases of imperfect self-fertility the fruitfulness might not be increased by treating the fruiting canes in some way to increase the supply of elaborated food available to the developing essential organs of the blossoms. In order to gain information on this subject, some experiments were conducted in 1901 and 1902, in which the transfer of elaborated food from the fruiting cane to the supporting branch or vine was checked either by girdling the cane just beyond its first node or by bending or twisting it

upon the trellis. This was done after the leaves began to appear but before the blossoms opened.

It is hoped that other tests may be made in which the operation of girdling or bending may be performed before the buds break, but this has not yet been done. After this work was started it was learned that ringing Zante grape vines is practised by the Greeks to promote setting of fruit, uniformity of bunch and increased size of berry.[1] A narrow ring of bark $\frac{1}{8}''$ to $\frac{1}{4}''$ wide is taken from the trunk when the fruit is setting. In a short time the bark grows over the incision. In our own work a similar plan was followed so far as the ringing of the cane is concerned. About three weeks before the blossoms opened some fruiting canes of certain varieties chosen for the experiment were girdled by removing a ring of bark $\frac{1}{4}''$ to $\frac{1}{8}''$ wide between the first and second nodes. At the same time certain other canes on corresponding vines of the same varieties were either tied so as to lie horizontally upon the trellis wire for about one-fourth of their length, then bend sharply and follow the next wire in the opposite direction, or were twisted at about one-fourth their length by being wound twice around the wire as tightly as possible without breaking them. Ten days later the clusters had developed enough so that the work of covering them with manilla paper bags was done. The blossoms had not yet begun to open at that time. At a suitable time when the blossoms were opening the clusters which were to be tested for self-fertility were cross-pollinated according to the method described on p. 273, or once, at least during the blooming season were shaken up thoroughly, without opening the bags containing them, for the purpose of mixing the pollen among the blossoms of the clusters. Where the former method was followed the clusters chosen to supply the pollen were, in all cases, produced on corresponding bent or girdled canes of the same variety, and often were borne on the same vine as the cross-pollinated clusters. They had been likewise inclosed in bags before blooming to prevent admixture of foreign pollen. Clusters thus treated will be hereafter referred to as "cross-pollinated," which signifies only that they were supplied with

[1] *Garden and Field* (Australia), cited in *Pac. Coast Fruit World*, May 24, 1901.

pollen from another cluster, always of the same variety and produced under corresponding conditions. Clusters which were shaken in the bag containing them, but which were not treated with pollen from another cluster, will be referred to as "close-pollinated," by this term meaning that no other pollen was supplied to them but that borne in the same cluster.

The wound made in girdling the cane usually healed readily, but occasionally it did not. An extreme case of failure to heal is illustrated in Plate XLII, Fig. 1.

At the close of the season the fruit clusters were rated on the basis of 100 points for a perfectly filled cluster. This rating was not based upon the size of the fruit as compared with normal specimens, but separate notes were made as to size of fruit, number of seeds, if any, and other features of interest. The results with each variety will now be presented.

BRIGHTON.

Brighton is usually self-sterile, but occasionally is slightly self-fertile.

On a girdled Brighton cane 5 clusters were cross-pollinated with pollen from other clusters on the same cane. They rated 60, 50, 60, 0, 0 respectively. Most of the fruits were below normal size and seedless. Some had abortive seeds and correlated with them an increase in size over the seedless fruits. Occasionally a berry was found of normal size and with normal sized seeds. Only one seed in all the lot had a well-developed endosperm. Total number of berries, 49. Number of abortive seeds, 23. Fig. 2, Plate XLII, shows one of these clusters.

On another girdled cane eight clusters were close-pollinated. These rated 90, 50, 0, 65, 40, 0, 0. All fruits were seedless except one, which had three abortive seeds. Total berries, 70. Fig. 3, pl. I, shows one of these clusters.

On a bent cane five clusters were cross-pollinated with pollen from other clusters on the same cane. No fruit set.

On a bent cane nine clusters were close-pollinated. No fruit set.

On a normal cane 10 clusters were close-pollinated. No fruit set.

CONCORD.

Concord is strongly self-fertile.

On a girdled cane five clusters were cross-pollinated with pollen from other clusters on the same cane. They rated 98, 90, 93, 91, 78. Fruit normal in size. Average seeds per berry, 1.42.

On bent canes 10 clusters were cross-pollinated with pollen from other clusters on the same canes. These rated 88, 93, 92, 95, 93, 90, 75, 88, 75, 75. Average seeds per berry, 1.90. Fruit normal in size.

On a normal cane 5 clusters were cross-pollinated with pollen from other clusters on the same cane. These rated 80, 90, 98, 90, 88. Average seeds per berry, 1.72. Fruits of normal size.

DELAWARE.

Delaware is strongly self-fertile.

On a girdled cane two clusters were cross-pollinated with pollen from other clusters on the same cane. These each rated 100. The fruits were of normal size. Average seeds per berry, 1.28.

On a normal cane five clusters were cross-pollinated with pollen from other clusters on the same cane. These rated 100, 92, 100, 100, 100. Number of fruits and seeds in one cluster was not recorded. The other four clusters averaged 1.31 seeds per berry.

ELDORADO.

In previous tests Eldorado has always been found self-sterile.

On a girdled cane five clusters were cross-pollinated with pollen from other clusters on the same cane. They rated 6, 0, 0, 0, 12. Total berries, 9. These varied from less than normal to very small in size. They produced only three seeds and these were abortive.

On a bent cane five clusters were cross-pollinated with pollen from other clusters on the same cane. No fruit formed.

On a normal cane five clusters were cross-pollinated with pollen from other clusters on the same cane. No fruit formed.

HERBERT.

In all tests Herbert has proved completely self-sterile.

On a broken cane six clusters, on a girdled cane six clusters, on a bent cane five clusters and on a normal cane six clusters were cross-pollinated with pollen from other clusters on the same respective canes. No fruit set in any case.

NIAGARA.

Niagara is strongly self-fertile.

On a bent Niagara cane six clusters were close-pollinated. These rated 95, 85, 98, 95, 97, 90. Average seeds per berry, 1.89. Fruit of normal size.

On a normal cane 10 clusters were close-pollinated. These rated 75, 90, 78, 92, 98, 92, 78, 93, 90, 90. Fruits were of normal size. Average seeds per berry, 2.17.

SALEM.

In all tests Salem has proved self-sterile.

On a girdled cane 10 clusters, and on bent canes 10 clusters, were close-pollinated. No fruit set.

VERGENNES, IN 1901.

This is classed among the imperfectly self-fertile varieties. When self-pollinated only it sometimes produces marketable clusters, but in many cases the clusters under such conditions are too unsymmetrical and too imperfectly filled to be marketable.

On a girdled cane 10 clusters were close-pollinated. One failed to develop further; possibly it was accidentally broken during the treatment. The other nine rated respectively 100, 60, 100, 88, 100, 100, 100, 98, 80. Fruit normal in size. Seeds averaged 1.84 per berry.

On a bent cane 10 clusters were close-pollinated. They rated 100, 60, 100, 88, 98, 90, 82, 88, 95, 85. Fruit normal in size. Seeds averaged 2.66 per berry.

On a normal cane 10 clusters were close-pollinated. They averaged 80, 96, 75, 95, 80, 80, 90, 88, 88, 100. Fruit normal in size. Seeds averaged 2.38 per berry.

The following season (1902) the tests with Empire State and Vergennes were repeated. The Empire State vine, which was girdled in 1901, proved to be unhealthy, and so the results were not reported.

VERGENNES, IN 1902.

On girdled canes five clusters were cross-pollinated with pollen from other clusters on the same canes. The girdle did not heal over. The fruit was more backward in ripening and smaller than normal Vergennes. The clusters rated respectively 45, 78, 88, 70, 50. Number of seeds was not determined.

On bent canes five clusters were cross-pollinated with pollen from other clusters from the same canes; 6 other clusters on these canes were not bagged, but were left open to cross-pollination. Taking these into account, the clusters on the bent canes were, on the whole, better developed and better filled than those on the same vine which were borne on unbent canes. The clusters rated respectively as stated below:

On bent canes bagged clusters rated 60, 50, 62, 75.

On bent canes unbagged clusters rated 100, 96, 97, 20, 95, 45.

On normal canes unbagged clusters rated 8, 70, 65, 75, 95, 38, 50, 85, 8, 15, 90, 75, 90, 50, 55, 80, 88, 85, 60, 35, 35, 55, 15, 12, 12, 18, 85, 25.

On a normal cane four clusters were cross-pollinated with pollen from other clusters on the same cane. These rated 75, 75, 65, 70.

In these tests the best results were obtained from uncovered clusters on bent canes. The covered clusters averaged somewhat better on the normal than on either the girdled or the bent canes.

EMPIRE STATE, IN 1902.

In previous tests Empire State has proved rather strongly self-fertile.

On girdled canes five clusters were cross-pollinated with pollen from other clusters on the same canes. They rated 100, 100, 100, 88. Fruit normal in size.

On bent canes five clusters were cross-pollinated with pollen from other clusters on the same canes. They rated 100, 100, 100, 90, 100.

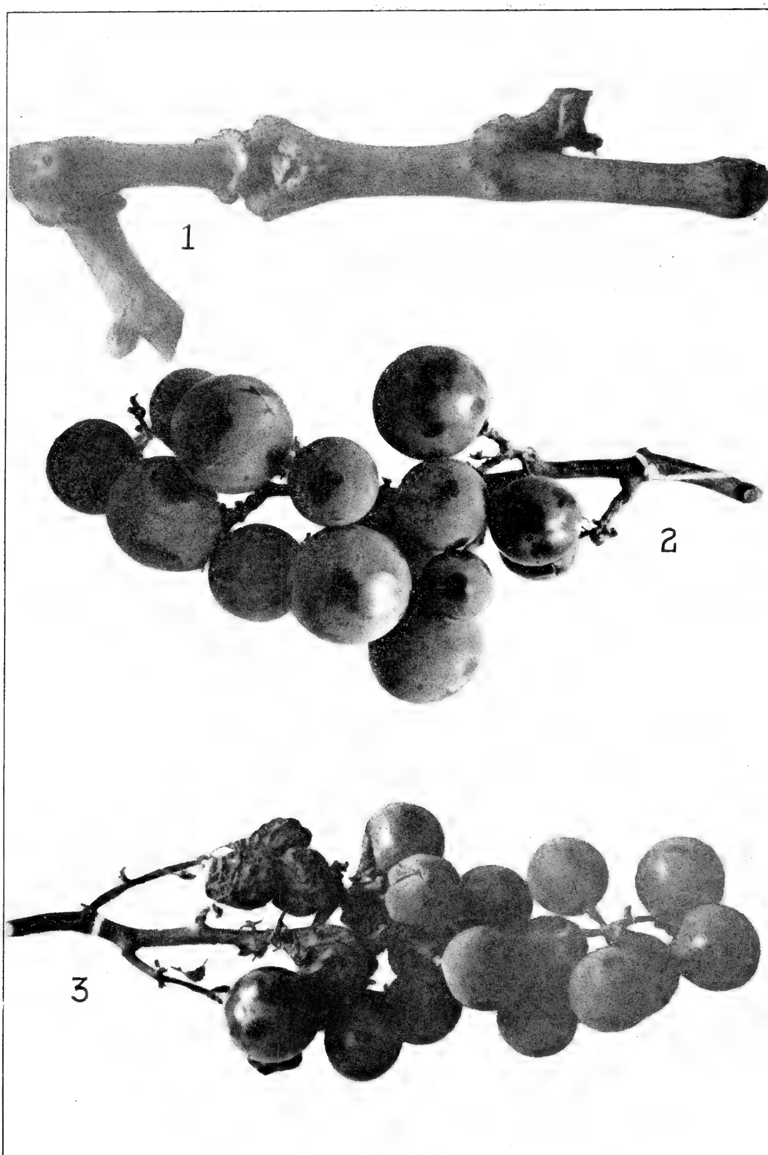

PLATE XLII.—EFFECT OF GIRDLING ON CANE AND FRUIT.

FIG. 1. FAILURE OF GIRDLE TO HEAL: AN EXTREME CASE.
FIGS. 2 and 3. BRIGHTON CLUSTERS ON GIRDLED CANES; EACH CLUSTER CROSS-POLLINATED WITH POLLEN FROM ANOTHER CLUSTER ON SAME CANE. BRIGHTON, SELF-POLLINATED RARELY SETS FRUIT.

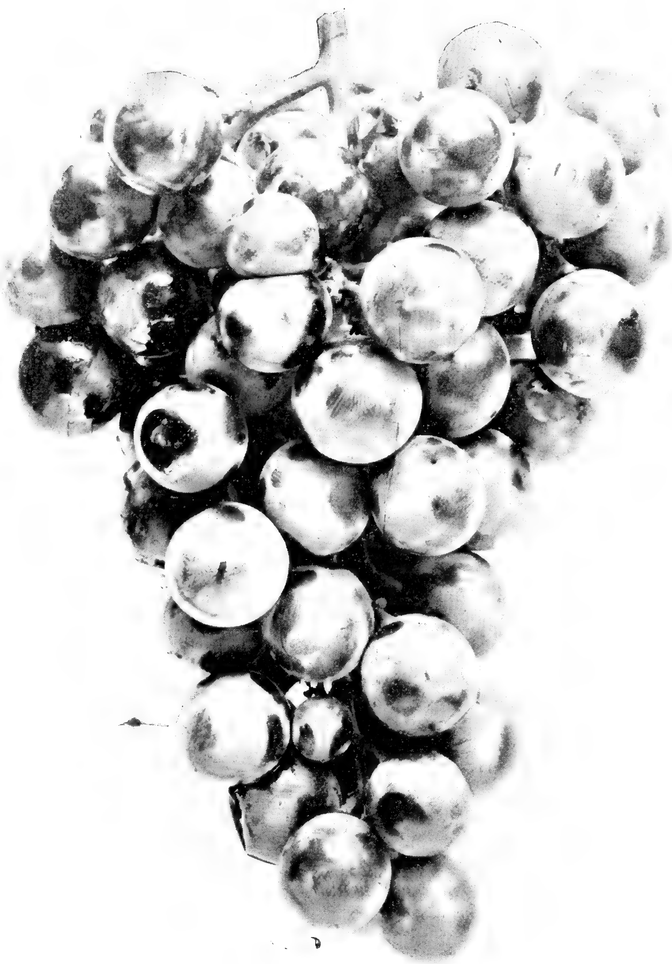

PLATE XLIII.—BRIGHTON BORNE ON NORMAL CANE: POLLINATED WITH STATION NO. 5, A STRONGLY SELF-FERTILE VARIETY.

On normal canes five clusters were cross-pollinated with pollen from other clusters on the same canes. They rated 100, 100, 100, 98, 100.

HERCULES, IN 1901.

In 1901 a Hercules vine trained to the four-arm Kniffen system was treated by having the lower north and upper south arms girdled. The upper north and lower south arms were left untreated. The clusters were all left open to cross-pollination. Hercules is self-sterile, but this vine usually bears fairly well because it stands in a mixed vineyard. The total number of clusters which developed fruit was 29 on the treated and 16 on the untreated canes. The weight of the fruit was 7.6 pounds on the treated and 4.6 on the untreated canes. In this case, as in the case where Vergennes was girdled and left open to cross-pollination, there is an apparent advantage from such treatment.

The results of the above-described tests are tabulated below.

TABLE V.— RESULTS OF GIRDLING OR BENDING THE CANES BEFORE THE BLOSSOMS OPEN.

Name.	Clusters tested.	Kind of cane.	Character of fruit.	AVERAGE RATING.[1] Clusters bagged and self-pollinated.[2]	Clusters not bagged. Open to cross-pollination.	Average seeds for fruit.[3]
Brighton..........	5	Girdled...	Mostly small and seedless.......	34	......	.02
Brighton..........	8	Girdled...	Mostly small and seedless.......	[5]35	......	0
Brighton..........	5	Bent.....	None...........	0	......	.....
Brighton..........	9	Bent.....	None...........	[5]0	......	.....
Brighton..........	10	Normal...	None...........	[5]0	......	.....
Eldorado..........	5	Girdled...	Mostly small and seedless.......	3.6	......	0
Eldorado..........	5	Bent.....	None...........	0	......	.....
Eldorado..........	5	Normal...	None...........	0	......	.....
Herbert...........	6	Broken in bending..	None...........	0	......	.....
Herbert...........	6	Girdled...	None...........	0	......	.....
Herbert...........	5	Bent.....	None...........	0	......	.....
Herbert...........	6	Normal...	None...........	0	......	.....
Salem.............	10	Girdled...	None...........	[5]0	......	.....
Salem.............	10	Bent.....	None...........	[5]0	......	.....
Concord...........	5	Girdled...	Normal.........	90	......	1.42
Concord...........	10	Bent......	Normal.........	86.4	......	1.90
Concord...........	5	Normal...	Normal.........	89.2	......	1.72
Delaware..........	2	Girdled...	Normal.........	100	......	1.28
Delaware..........	5	Normal...	Normal.........	98.4	......	1.31
Empire State......	5	Girdled...	Normal.........	97.6	......	.....
Empire State......	5	Bent.....	Normal.........	98	......	.....
Empire State......	5	Normal...	Normal.........	99.6	......	.....
Niagara...........	6	Bent.....	Normal.........	[5]93.7	......	1.89
Niagara...........	10	Normal...	Normal.........	[5]87.6	......	2.17
Vergennes, 1901....	10	Girdled...	Normal.........	[5]91.8[4]	......	1.84
Vergennes, 1901....	10	Bent.....	Normal.........	[5]88.6	......	2.66
Vergennes, 1901....	10	Normal...	Normal.........	[5]87.2	......	2.38
Vergennes, 1902....	5	Girdled...	Normal.........	66.2	......	.....
Vergennes, 1902....	5	Bent.....	Normal.........	59.4	......	.....
Vergennes, 1902....	6	Bent.....	Normal.........	.....	75.5	.....
Vergennes, 1902....	....	Normal...	Normal.........	71.3	......	.....
Vergennes, 1902....	28	Normal...	Normal.........	.....	52.6	.....
Hercules..........	....	....	....	.....	[6]	.....

[1] The clusters were rated on the basis of 100 points for a perfectly filled cluster.

[2] For full significance of this term see p. 376. Unless otherwise indicated these averages are for cross-pollinated clusters.

[3] Seeds apparently abortive not included.

[4] Possibly this rating should be 82.6. See page 385.

[5] Clusters close-pollinated. See note 2.

[6] The record of results with Hercules favored the girdling operation and leaving the clusters open to cross-pollination. See page 387.

From the results shown with Hercules and with those Vergennes clusters on a bent cane which were left open to cross-pollination it appears that the treatment stimulated to greater productiveness. Some evidence of such stimulation is also found in the cases of Brighton and Eldorado. Sample clusters of the former are shown in Figs. 2 and 3, Plate XLII. For comparison with them a cluster of Brighton hand-pollinated with a pollen of a self-fertile sort is shown in Plate XLIII. The treatment of the self-sterile Herbert and Salem failed to cause them to fruit.

The self-sterile varieties Concord, Delaware, Empire State and Niagara have generally a higher average rating on girdled than on untreated canes, but the advantage of the treatment, if any, is not striking.

If the girdling can be used on such nearly self-sterile varieties as Brighton and Eldorado, or such imperfectly self-fertile kinds as Vergennes, when these varieties stand in proximity to strongly self-fertile kinds and are exposed to cross-pollination from them throughout the blooming season, it may be that their productiveness may be thus profitably increased. Further investigations should be made on this point, as well as a comparative study of early and late girdling.

A STUDY OF GRAPE POLLEN.*

N. O. Booth.

SUMMARY.

I. The self-sterility which is known to exist among many varieties of cultivated grapes is in many cases, if not all, due to a lack of potency in the pollen.

II. This lack of potency is indicated in the pollen grains by a shape which is quite different from that of potent pollen.

III. It is also shown in the arrangement of the pollen either dry or in liquid media.

IV. Certain varieties of grapes bear pollen in which both the potent and impotent forms are mixed. Trial of this mixed pollen shows that the amount which germinates is approximately in proportion to the potent forms present.

INTRODUCTION.

The following investigations were carried on in the summer of 1902. They are a continuation of some work started by Professor S. A. Beach as far back as 1892, the general object of which was to determine what varieties of grapes are self-sterile and what other varieties are best to use as pollinizers for these self-sterile sorts.[1] One of the first questions that comes up in such an investigation is, naturally: What causes self-sterility in the grape? There are several causes which might produce this condition: (1) What is known to botanists as dichogamy, or the pistils and stamens from the same blossom and usually from the same plant maturing at different periods; (2) lack of affinity between pollen and pistil from the same plant so that even

*Reprint of Bulletin No. 224.

[1]See Bulletins Nos. 157, 169 and 223 of this Station.

though pollen falls on the pistil fertilization does not result; (3) the pollen itself being so scanty as to render fertilization improbable if not impossible; (4) lack of viability in the pollen itself rendering it impotent not only on its own pistil but also on all others. For reasons which will be discussed in the latter part of this paper the writer considered that the first and second of these causes are not probable ones. The third seemed quite probable and the results secured by Beach and published in Bulletin No. 169 seemed to indicate that the fourth was one of the causes, if not the only cause, why certain varieties of grapes should be self-sterile; as the results there showed that the pollen of self-sterile grapes so far as tested was not generally potent on other self-sterile sorts.

INVESTIGATION.

AMOUNT OF POLLEN.

This year observations were made on a great many different varieties of grapes as to the amount of pollen present. All of the estimates were of course approximate since pollen is a substance which it would be very difficult if not impossible to measure with any degree of exactness. These observations were made both with the naked eye and simple lens. There were great variations in the quantity of pollen present on the different blossoms, but the variations did not appear to be particularly significant.

There were greater variations on different clusters of the same vine than normally appeared on different vines of different varieties. The last clusters of flowers to bloom, and sometimes the first, are usually not so well supplied with pollen as those which appear at the height of the blossoming season. Vines just coming into bearing and having only one or two clusters on the vine were usually scantily supplied with pollen. With some of the varieties, even where there was no apparent cause in the condition of the vine, the amount of pollen present was apparently insufficient to make pollination at all certain. However, with most of the self-sterile varieties the pollen was quite plentiful and apparently quite sufficient for pollinating purposes.

LABORATORY STUDY OF POLLEN.

At the same time that these observations were being made the pollen itself was being studied to determine if possible its status as a factor bearing on fertilization. This part of the work was wholly of a laboratory and microscopic nature, the only portion which took place in the field being the gathering of the blossoms. For this purpose the following varieties were selected for examination and comparison.

TABLE I.—VARIETIES OF GRAPES SELECTED FOR COMPARISON OF POLLEN.

PERCENTAGE.	SELF-STERILE VARIETIES.			SELF-STERILE VARITIES.		
	No.	Variety.	Class.[1]	No.	Variety.	Class.[1]
Riparia x.......	1	Clevener......	4	1	Clinton.........	2
Riparia x.......	2	Marion........	3	2	Janesville.......	1
Riparia x.......	3	Elvibach......	4	3	Berckmans......	1
Labrusca x.......	4	Aminia........	4	4	Agawam........	2
Riparia x.......	5	Grein Golden..	4	5	Missouri Reisling	2
Labrusca x.......	6	Barry.........	4	6	*Rogers No.* 32....	2
Labrusca x.......	7	Wyoming.....	4	7	Lucile..........	1
Labrusca x.......	8	Black Eagle...	4	8	Triumph........	2
Labrusca x.......	9	Massasoit.....	4	9	Brilliant........	2
Labrusca x.......	10	Roscoe.......	4	10	Lindmar........	2
Lincecumii........	11	Hexamer.....	4	11	Bailey..........	2

Here we have a comparison, in each instance, of two varieties blooming at the same or nearly the same time, with similar parentage, but one variety being self-sterile and the other self-fertile, the object being to eliminate so far as possible all differences which might be due to species or strain. These investigations were along the two general lines: (1) Trial of the pollen in sugar solution to see if it would germinate; (2) examination of the pollen under a microscope to see if there were any constant morphological differences between that of the self-sterile and self-fertile varieties.

[1]The numbers under "Class" refer to classification given by Beach in Bulletin No. 157; Class 1 includes varieties in which sacked blossoms gave clusters varying from perfect to somewhat loose; Class 2, clusters marketable—moderately compact or loose; Class 3, clusters unmarketable; and Class 4, self-sterile—no fruit developed on covered clusters.

CULTURES.

In 1 per ct. sugar solution.— The results from the first four kinds of pollen tested were uncertain. This was due to using a sugar solution which was too weak for this kind of pollen to make a good growth (1 per ct.). The only difference shown in this pollen was in the budding, which is the first stage in pollen germination. See Fig. 1. None germinated. The Clinton and Janesville both showed buds on from 5 to 10 per ct. of the grains, but the Clevener and Marion showed at the end of four days no change from their condition at time when placed in solution.

In 2 1-2 per ct. sugar solution.— On June 18 pollen grains of Elvibach, Berckmans, Aminia and Agawam were placed in hanging drops of 2½ per ct. sugar solution. They were examined for three successive days thereafter and the number of germinations noted. The Elvibach and Aminia pollen did not germinate or even bud. About 4 per ct. of the Berckmans germinated and about 10 per ct. of the Agawam.

In 5 per ct. dextrose solution.—On June 21 pollen was prepared as before, using a 5 per ct. solution of dextrose in place of the previous medium. The varieties from which pollen was taken in this instance were Grein Golden, Missouri Reisling, Barry, *Rogers No. 32,* Wyoming and Lucile. Notes were taken on these cultures on June 23, at which time they were in the height of their growth, none germinating after that date. At this time the pollen grains of the Grein Golden, Barry and Wyoming had not changed in any way from their condition when they were first placed in the solution. About 12 per ct. of the Missouri Reisling germinated, 20 per ct. of *Rogers No. 32* and 10 per ct. of the Lucile.

In 10 per ct. dextrose solution.—Pollen of these same varieties was placed at this latter date in 10 per ct. dextrose solution with the following results: Out of an estimated 200 grains of pollen of Grein Golden, one made a very weak growth; Barry and Wyoming pollen grains not changed in any way; Missouri Reisling, about 15 per ct. germinated; *Rogers No. 32,* about 50 per ct. (especially strong); Lucile was accidentally destroyed.

In 10 per ct. sugar solution.— The same varieties were tried in 10 per ct. sugar solution with the following details: Of Grein Golden, out of an estimated 150 grains one germinated, growth short and weak; Missouri Reisling, 20 per ct. grew; Barry none; *Rogers No. 32,* about 75 per ct. good and strong; Lucile, at least 80 per ct., a mass of growth.

In 20 per ct. sugar solution.—In 20 per ct. sugar, Grein Golden shows 2 in approximately 250; Missouri Reisling 25 per ct., Barry, none; *Rogers No. 32,* 90 per ct.; Wyoming, about 5 per ct. (growth weak); Lucile, 95 per ct.

On July 2 cultures were made in 20 per ct. sugar solution with pollen of Black Eagle, Triumph, Massasoit, Brilliant, Roscoe, Lindmar, Hexamer and Bailey. Notes taken the following day show: Black Eagle, none budded or grown; Triumph, practically all budded, but only about 10 per ct. grown to any length; Massasoit, little budding and no growth; Brilliant, all budded, 60 per ct. grown; Roscoe, none budded and none grown; Lindmar, about 60 per ct. budded and 10 per ct. grown; Hexamer, no buds and no growth; Bailey, about 60 per ct. budded and 5 per ct. grown. The foregoing results are tabulated below:

TABLE II.— GERMINATION OF POLLEN GRAINS IN CULTURES.

Name of variety.	Class.	Fertility or sterility as determined by previous field experiments.	Date when placed in solution.	Date when examined.	Solution used for germination.	Percentage of germinations.
					Per ct.	*Per ct.*
Elvibach	4	Sterile	June 18	June 19	2½ sugar	0
Berckmans	1	Fertile	June 18	June 19	2½ sugar	4
Aminia	4	Sterile	June 18	June 19	2½ sugar	0
Agawam	2	Fertile	June 18	June 19	2½ sugar	10
Grein Golden	4	Sterile	June 21	June 23	20 sugar	1 weak
Mo. Reisling	2	Fertile	June 21	June 23	20 sugar	25
Barry	4	Sterile	June 21	June 23	20 sugar	0
Rogers No. 32	2	Fertile	June 21	June 23	20 sugar	90
Wyoming	4	Sterile	June 21	June 23	20 sugar	5
Lucile	1	Fertile	June 21	June 23	20 sugar	95 very strong
Black Eagle	4	Sterile	July 3	July 5	20 sugar	0
Triumph	2	Fertile	July 3	July 5	20 sugar	10
Massasoit	4	Sterile	July 3	July 5	20 sugar	0
Brilliant	2	Fertile	July 3	July 5	20 sugar	60
Roscoe	4	Sterile	July 3	July 5	20 sugar	0
Lindmar	2	Fertile	July 3	July 5	20 sugar	10
Hexamer	4	Sterile	July 3	July 5	20 sugar	0
Bailey	2	Fertile	July 3	July 5	20 sugar	5

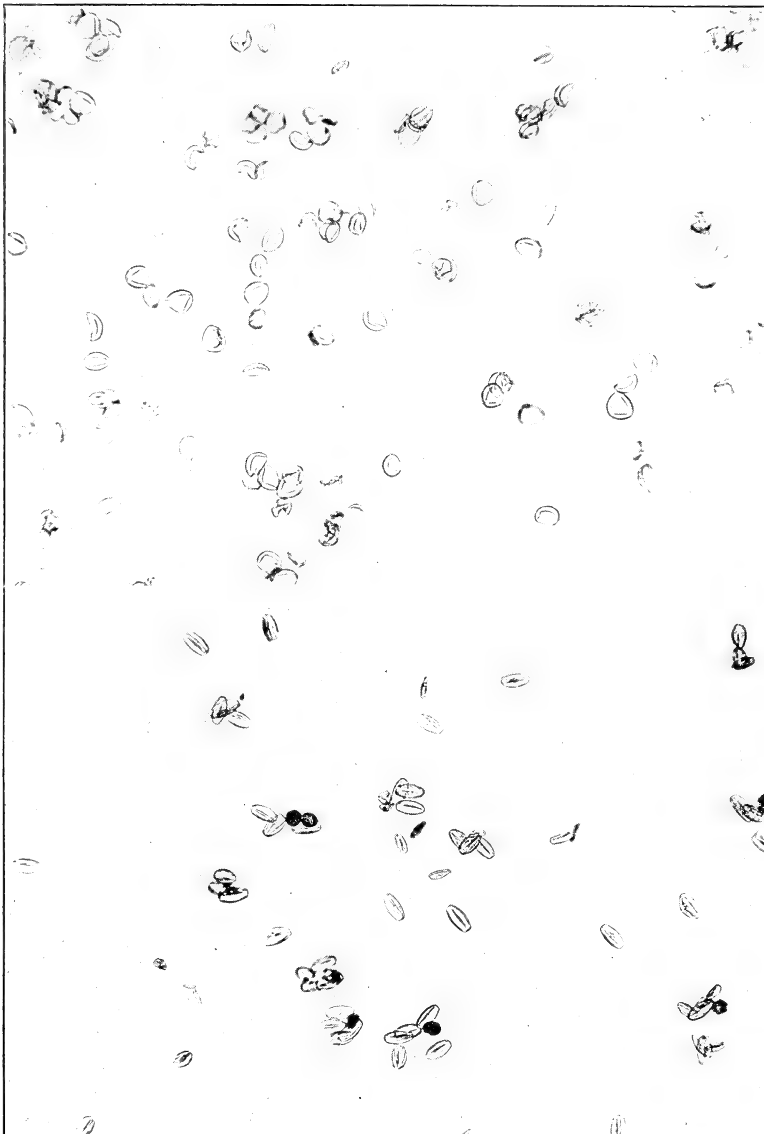

PLATE XLIV.—GRAPE POLLEN:

UPPER.—GREIN GOLDEN, SELF-STERILE, CLASS 4.

LOWER.—MISSOURI RIESLING, SELF-FERTILE, CLASS 2.

(For classification see footnote to table I.)

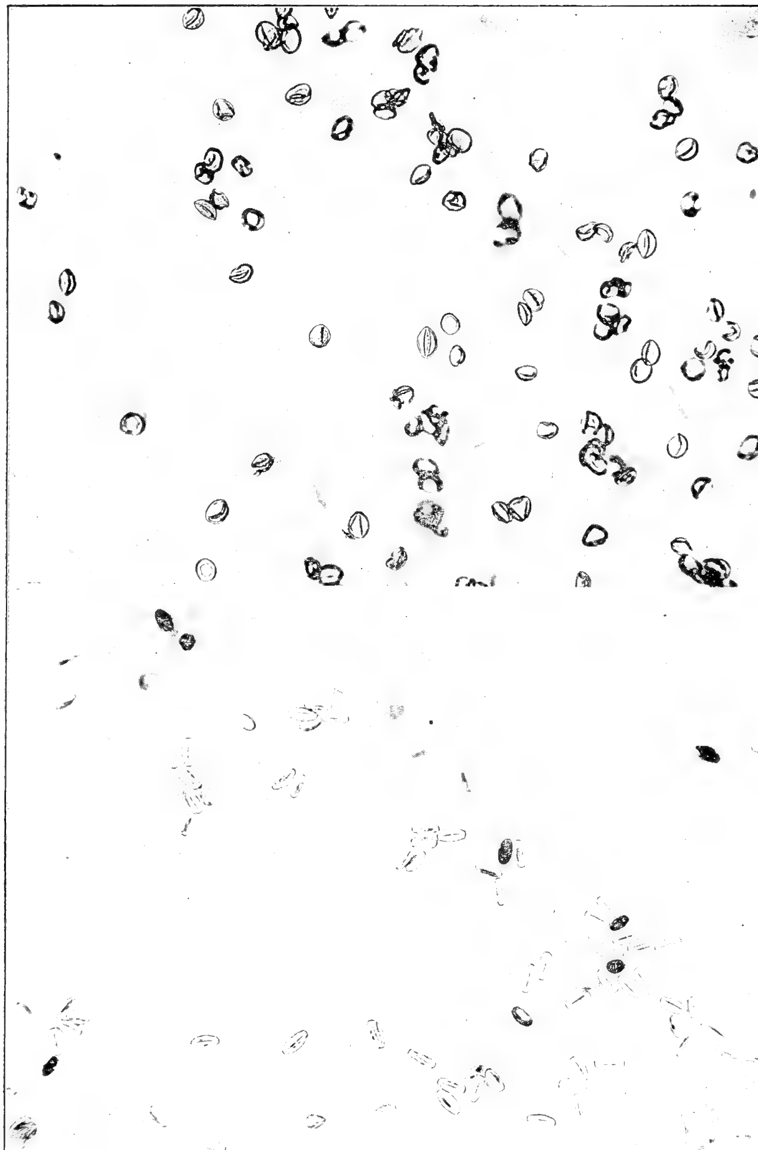

PLATE XLV.—GRAPE POLLEN:

UPPER.—BARRY, SELF-STERILE, CLASS 4.

LOWER.—ROGERS NO. 32, SELF-FERTILE, CLASS 2.

(For classification see footnote to table I.)

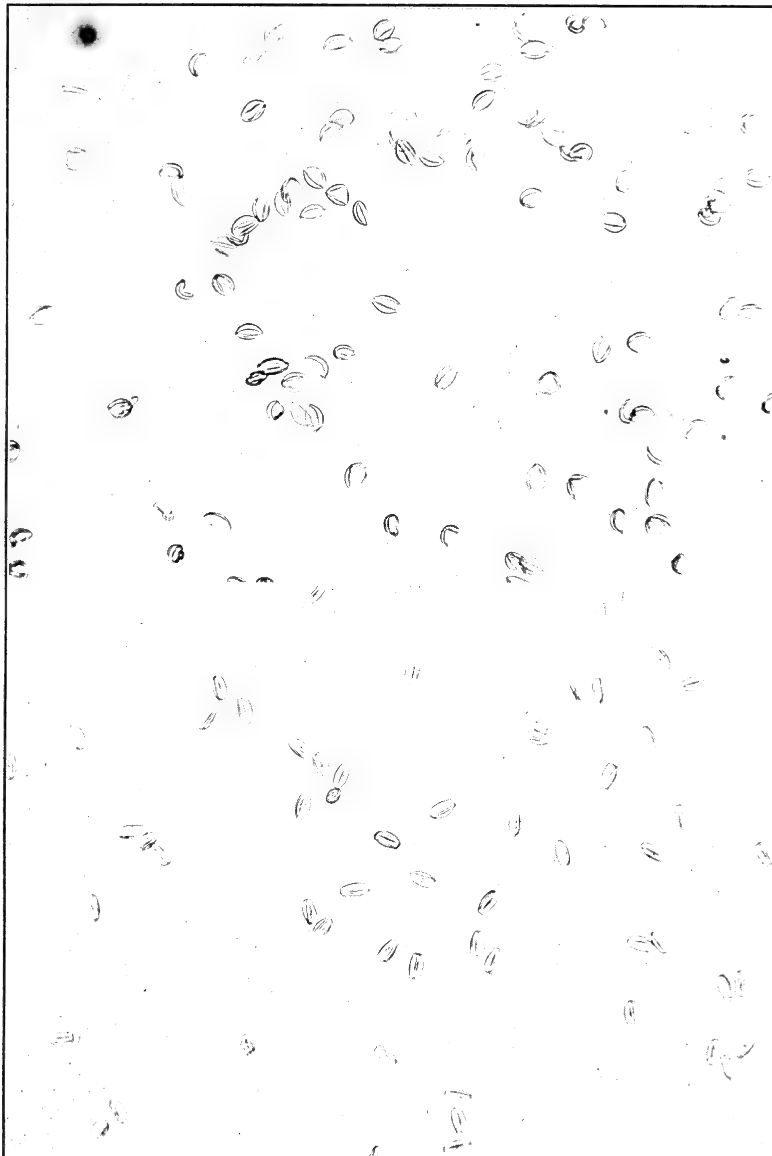

PLATE XLVI.—GRAPE POLLEN.

UPPER.—BLACK EAGLE, SELF-STERILE, CLASS 4.
LOWER.—TRIUMPH, SELF-FERTILE, CLASS 2.

(For classification see footnote to table I.)

PLATE XLVII.—GRAPE POLLEN.

UPPER.—WYOMING, SELF-STERILE, CLASS 4.

LOWER.—LUCILE, SELF-FERTILE, CLASS 1.

(For classification see footnote to table I.)

PLATE XLVIII.—GRAPE POLLEN.

UPPER.—MASSASOIT, SELF-STERILE, CLASS 4.

LOWER.—BRILLIANT, SELF-FERTILE, CLASS 1.

(For classification see footnote to table I.)

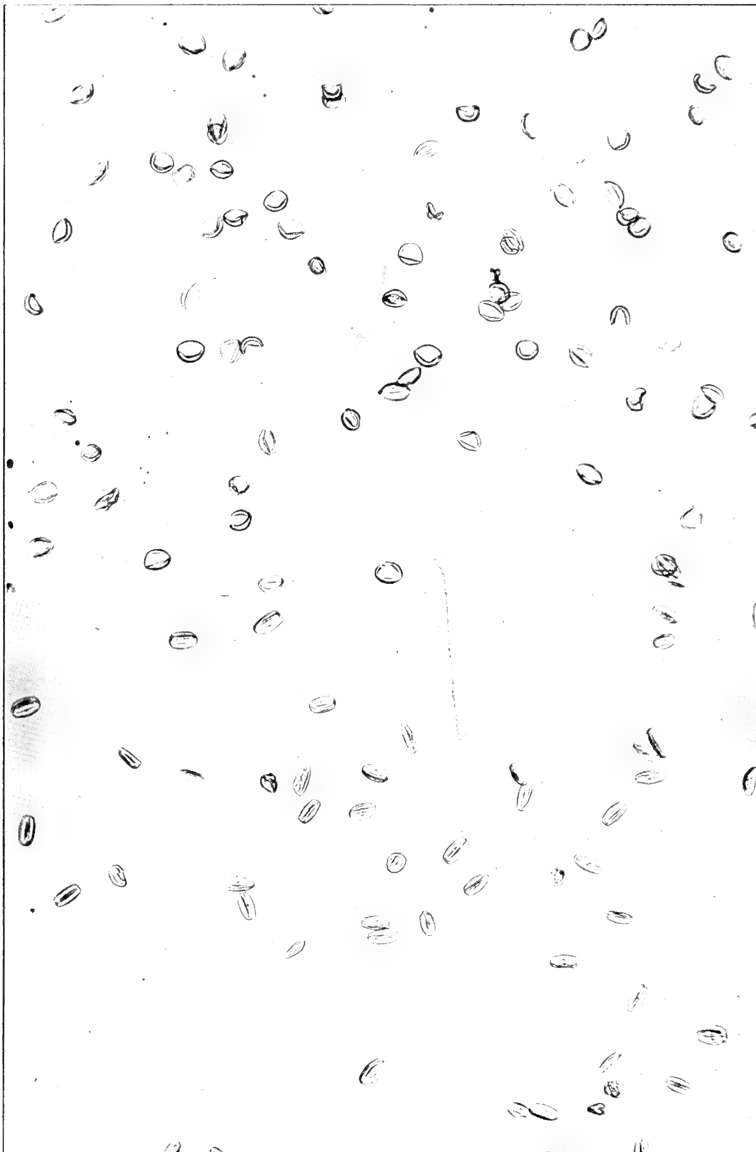

PLATE XLIX.—GRAPE POLLEN.

UPPER.—HEXAMER, SELF-STERILE, CLASS 4.

LOWER.—BAILEY, SELF-FERTILE, CLASS 2.

(For classification see footnote to table I.)

MICROSCOPIC EXAMINATION.

Besides these there is another difference between the self-sterile and the self-fertile pollen which is noticed on microscopic examination and which seems to be constant. The self-fertile grains seem to be surrounded by a mucilaginous substance which makes them stick to one another more or less so that the pollen whether it lies dry on the slide or is placed in liquid media arranges itself in a succession of clumps. This mucilaginous substance does not appear to be soluble in water as the pollen grains retain their respective positions even after several days in the solutions. The self-sterile pollen, on the other hand, shows no such arrangement but the grains distribute themselves either on the slide or in the liquid like so much dry powder, quite by chance.

The next phase of the work was the microscopical examination of the dry pollen grains to see if there were any characteristic differences in the size or shape of the different classes of pollen. All pollen, whatever its shape may be when it comes from the anther, swells on contact with water and most other liquids, assuming an approximately spherical shape. Consequently these studies had to be made with the dry pollen. The results of this part of the work can be better illustrated than told. On the preceding pages are cuts which are reproduced from photo-micrographs of the pollen mounted in balsam. The characteristic differences are very apparent. The self-fertile forms are oblong, blunt at the ends and quite symmetrical. The self-sterile sorts, as may be seen, are quite different in shape, being more irregular and usually more pointed than those of the other class. Pollen from all other varieties in the list previously given showed these same shapes according to the class to which the variety in question belonged, but the blooming season of the first eight varieties was past before I thought of illustrating this phase of the work, and later the balsam mounts of Roscoe and Lindmar were accidentally destroyed so that illustrations of these cannot now be presented.

Examination of pollen from varieties of grapes which had given conflicting results in Prof. Beach's work to determine if they were self sterile showed that the self-sterile and the self-fertile forms may be mixed in the same variety. Eaton was the first one of

these varieties which was examined on June 26. The pollen of this variety is quite irregular in shape and size and only about 10 per ct. show the regular self-fertile shape, although there are numerous others which approach it very closely. Its grains are considerably larger than those of average pollen. In 20 per ct. sugar solution about 15 per ct. of this pollen germinated. None of the growths appeared healthy however or at least were not like those of completely self-fertile pollen. In normal self-fertile pollen the tubes formed on germination are approximately the same size throughout, but the tubes of Eaton varied in size at different points of their course, being restricted at one place and swollen and distorted at another. The tubes were fully as long as those of normal self-fertile pollen. Other varieties which Prof. Beach has determined as belonging to the same doubtful class are

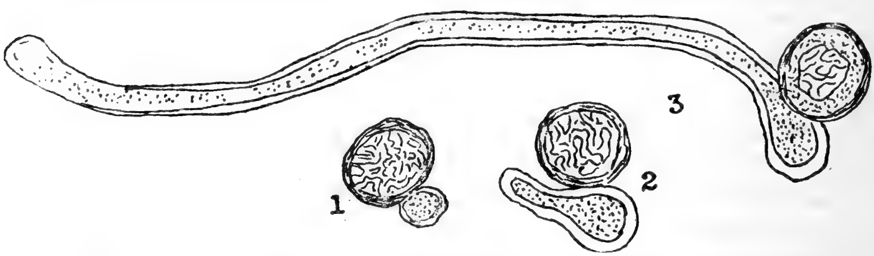

FIG. 1.—GRAPE POLLEN AT DIFFERENT STAGES OF GROWTH.
1, A Grain which has just Budded; 2 and 3, More Advanced Stages of Growth

Dracut Amber, Maxatawney, Faith, Geneva, Montefiore, Canonicus, Oneida, Gold Dust and White Jewell. Pollen of these was tested as was also that of Red Trauminer, Red Veltliner and Chables sent by Dr. Tinker of Ohio. In each instance the percentage of pollen which germinated did not vary widely from the percentage of self-fertile forms which the microscope showed that particular variety to contain. And it appears very certain that the capacity of the pollen for growth is in direct proportion to the number of self-fertile forms present and their conformity to the self-fertile type. Pollen of the different varieties of grapes varies considerably in size, but there is no apparent connection between the size and the germinating capacity.

These results seem to confirm those previously secured in the field in showing that one of the reasons why certain varieties of grapes are self sterile is a lack of viability or potency in the pollen

itself.[1] There may be other minor factors such as quantity of pollen produced, lack of affinity, etc. but this one is sufficient to account for all of the phenomena observed both in the field and laboratory.

These results raise the question in the author's mind as to whether the grape is not now, so far as its phænological characters are concerned, in a state of evolution from an older hermaphrodite form to forms that are essentially staminate and pistillate. All of the staminate flowers, so called, which I have observed have small abortive pistils; which also conforms with the observations of Engelman.[2] Others report staminate flowers with no trace of pistil remaining. On the other hand the most advanced pistillate forms still retain their stamens although so far as their true function is concerned they are apparently abortive. There is considerable corroborative evidence that this incomplete evolution has taken place. The whole path is marked by transitional forms; thus there are no distinct classes of self-sterile and self-fertile grapes but all gradations exist from one extreme to the other.[3] This blending is quite apparent from an examination of pollen from a dozen or two of varieties selected by chance. In selecting the varieties which are given in the list in the early part of this bulletin extreme types were chosen purposely so that any difference which might exist would be most apparent. It further appears that pollen from the same variety may vary slightly in different years and even the same year in different localities.[4] These facts seem to show that our grape is in a state of very unstable equilibrium, coming from an ancestry of diverse sexual types.[5]

It might be interesting to consider the probable cause of this evolution. It seems reasonable to suppose that there must be some advantage which the staminate and pistillate vines have

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[1]Such plants are well known and are called by botanists pseudo-hermaphrodites. I am not aware, however, that any of our cultivated plants have been heretofore recognized as belonging to this class. See Natural History of Plants, by Kerner, page 291.

[2]Bushberg Catalogue, page 7. (Edition of '95.)

[3]See Bul. No. 157: 424 et seq.

[4]Beach, Bul. No. 157: 424. Bushberg Catalogue, page 8. There is a vine on this station which bears both staminate and hermaphrodite flowers. Mr. N. B. White, Norwood, Mass., reports that he has a male (?) Rip. X Lab. vine which has fruited twice in the last thirty years, the pistils evidently varying in strength but being generally too weak to produce fruit.

[5]Natural History of Plants, page 300.

over the assumedly older hermaphrodite forms, or they would not have developed and persisted. This advantage is supposed to lie in the fact that cross-fertilization is thus assured. The seedlings resulting from cross-fertilization being usually the stronger[1] would have the better chance in the struggle for existence with those from vines which were self-fertilized. However, we should not lose sight of the fact that there are also some advantages to the hermaphrodite forms and the chief one of these lies in the greater certainty of fertilization and consequent seed production. Thus where vines are widely scattered the hermaphrodites would have the advantage since the chances of cross-fertilization of the staminate and pistillate forms would be remote. Where the conditions are such that vines are numerous and closely adjacent the opposite would be the case, as fertilization of the pistillate flowers would be comparatively certain and the seedlings resulting would have the advantage over those resulting from self-fertilized hermaphrodites. It must be remembered that the adjacency referred to is not merely a matter of distance but would be modified more or less by other factors such as number and kind of insects normally present, direction of winds, surrounding vegetation, etc. It must also be remembered that although pistillate flowers are necessarily cross-fertilized it does not follow that hermaphrodite flowers are necessarily self-fertilized. These may be cross fertilized also either by other hermaphrodites or by staminates, and the pistillate forms may be pollinated by either the staminates or hermaphrodites. In any of these cases the resulting seedling, while it would possess the individual vigor due to crossing, might be itself in any class so far as its phænological characters are concerned. This mixing and the fact that the advantages of each class tend to a certain extent to balance each other probably accounts for it that neither form has supplanted the other but both are still present. In reference to the question referred to in the first part of this bulletin as to whether dichogamy or the maturing of stamens and pistils on the same plant at different periods might exist in the grape, observations seem to show that this does not exist. The anthers usually burst and the pollen

[1]Cross and Self-Fertilization in the Vegetable Kingdom. Darwin.

is liberated before the stigmas become receptive, but a good portion of the pollen remains on the anther and is gradually released even some time after the pistils are in condition to be fertilized. Grape pollen is notably resistant to the ordinary influences of decay,[1] and it can be readily seen how in an inconspicuously flowered plant like the grape, where insect visits might not be so numerous as would be desired for pollinating purposes, keeping qualities on the part of the pollen grains would be so valuable a factor that it could not be sacrificed even for so important a consideration as cross-fertilization. The question as to whether there may not be a lack of affinity between the pollen of a self-sterile grape and its own pistil will be difficult to settle conclusively, and yet the foregoing evidence seems to show that such lack of affinity does not exist, since poor pollen was found in all those varieties examined of the self-sterile class, and only in those of this class. Furthermore, the phænological evolution referred to, if this be accepted as a fact, is strong negative proof that lack of affinity does not exist, for if any of the original hermaphrodite forms had possessed that quality by which pollen of a certain plant is impotent on the pistils of the same plant at the same time being good on all others then there would have been no cause to produce the staminate and pistillate forms of to-day, for cross-fertilization would have already been assured.

The economic bearing of these results is quite apparent. It has heretofore been necessary in order to determine whether a certain variety of grape was self-fertile or not to sack certain clusters before the blossoms opened and see if any fruit set with the pistils thus protected from the entrance of outside pollen. These operations, besides taking considerable time, are subject to all the accidents which are apt to occur when such delicate work is being done in the field. The pressure of the sack may destroy the pistil or the sack itself may be knocked off by persons or storms, and there is always the possibility of the accidental entrance of other pollen. In careful experiments all this is provided for by duplicating the sacks until the chances are

[1]Bul. No. 157, page 438. Pollen was germinated at this Station this year three weeks after it had been gathered in California.

very small of such accidents vitiating the results. But all this adds to the work, whereas by the use of the microscope the sexual status of a variety may be determined in a few minutes so far as that season is concerned. The older cultivated varieties in the east have nearly all been determined, but there are still some of these which are doubtful and the new varieties as they are originated can be determined the first season they blossom.

It is not unreasonable to expect that observations as to the quantity and condition of the various kinds of pollen will give us better rules for the selection of fertilizers than we have at present. It may at times be of use to determine a certain variety; to illustrate, Lucile and Wyoming closely resemble each other in fruit and in certain other characters, but they may be distinguished by the fact that one has self-fertile pollen and the other self-sterile.

To the hybridist this work may be of some interest since it will indicate at once all possible male parents.

It is intended to continue this work next season and it is hoped to have some further data to report.

TREATING TREES THAT HAVE BEEN INJURED BY MICE OR RABBITS.*

N. O. Booth.

So many inquiries have been received by the Station as to the proper method of treatment for trees that have been injured by mice that it has been deemed advisable to issue this circular.

From the investigations carried on by different ornithologists on the feeding habits of birds, it is evident that one of the reasons, perhaps the chief one, for the presence of the great number of field mice is the indiscriminate killing of hawks and owls. While some species of these birds, now very seldom found, destroy many chickens and beneficial birds, the hawks, and certainly the owls most commonly killed, live almost wholly on field mice and similar pests.† The average hunter and most farmers' boys do not distinguish between them, but shoot every hawk and owl on sight. And it is an unfortunate fact that some of the most beneficial kinds of these birds are the least able to protect themselves and consequently are most liable to be killed.

Mice and rabbits injure trees in the winter by gnawing the bark. One of the most commonly used and most successful methods of preventing injuries from mice is to mould the earth up around the base of the trees in the fall. Mice can reach trees thus prepared only by climbing this conical mound, which they will rarely do. Any trash around the base of a tree will invite mice, and trees so situated are more apt to suffer from their depredations. Raking and burning whatever trash there is in the orchard will be beneficial as mice will not remain on open ground or in places where they cannot get food and shelter

*Reprint of a circular.

†See U. S. Dept. of Agr., Year Book, 1894: pp. 215–232. "Hawks and Owls from the Standpoint of the Farmer."

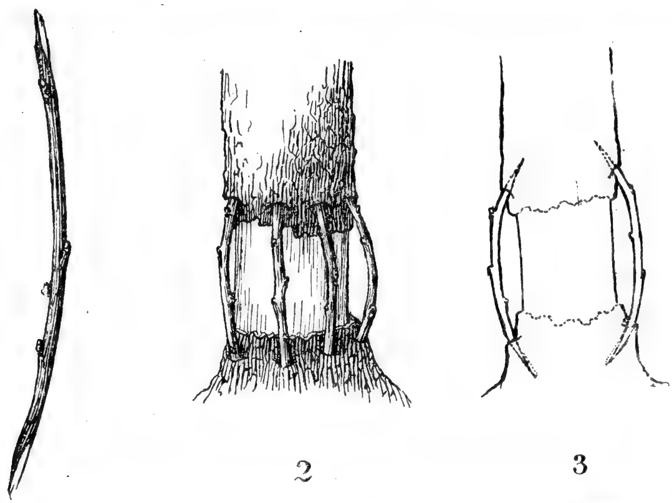
in cold weather. The gnawing of trees by rabbits indicates a want on the part of the animal of something green, and some nurserymen find ample protection from their ravages by scattering corn fodder or other substances that rabbits crave amongst their plantings. Injuries from rabbits are usually worst at times when snows have covered such green stuff as they are in the habit of eating. Hence if it is desired to decoy rabbits from trees by furnishing stuff they like better, it is necessary to scatter fresh material after each heavy snow. Rabbits will not bother anything that has been tainted by contact with raw meat or blood; and protection, for a time at least, can be secured by rubbing the bark of all young trees liable to be injured, with a piece of fresh meat. Veneer wrappers or any close covering will protect trees from rabbits and usually from mice, but the expense of securing and putting on such covering is considerable.

The seriousness of injuries from rabbits and mice, and consequent treatment, depend, naturally, on the depth and extent of the wound. If the wound does not extend through the bark into the sapwood, the cambium underlying the injury will seldom die and in these cases all that is desired is to prevent drying out of the wound. For this purpose there is nothing better than an application of grafting wax. (For a good stiff grafting wax, melt together 7 parts resin, 2 parts beeswax and 1 part tallow by weight.) Applications of bandages, earth, dung, etc., are often recommended, but by keeping the surfaces of the wound damp they furnish favorable conditions for the growth of decay germs and may do more harm than good. When the injury does extend through the bark into the sapwood, the cambium being destroyed, such a wound must heal from the side. If the extent of the wound be slight in comparison with the circumference of the tree no treatment is necessary, beyond that already mentioned, and the injury will usually be covered by the overlapping growth within a short time. Where the deep injury extends over one-fourth of the distance around the tree it is advisable, however, to use some artificial means of hastening the healing process.

In order to understand the function of any process of bridging over a girdle it is necessary to consider the sap flow of woody plants. In general it may be said that crude sap after it is taken up by the roots passes into the upper portion of the tree or shrub through the sapwood; that is, the wood of the last two or three years' growth. After this sap has been elaborated in the leaves and returns to build up the plant tissue it is passed almost wholly through the phloem or inner bark. When it comes to a point where the inner bark has been destroyed it may pass in through the sapwood and thus continue downward, but any such passage is difficult and slow. In an ordinary girdling, the sapwood, where the ascending current of sap passes, is practically uninjured so that the upward flow of crude sap is not interfered with to an appreciable degree. Hence trees which have been girdled will usually leaf out all right in the spring; but the parts below the injury not being able to secure any elaborate sap from the leaves above, no new roots can be formed and the plant later dies from lack of root nourishment. Hence the object of the operation described below is to bridge over the injury so that the descending stream of sap in the inner bark may pass to that portion of the tree below the wound.

To make such a bridge, first, take a twig, preferably of last year's growth, although this is not necessary, and with a sharp knife sharpen this twig to a wedge at both ends as shown in Fig. 1. This twig should be slightly longer than the distance across the wound, measuring up and down the tree, and should be stiff enough so that it will not bend easily. Next take a half-inch chisel and make an incision in the tree just above the girdle. This incision is made with the bevel of the chisel outward and the edge extending upward and inward through the bark into the wood. A similar incision is made just below the wound and directly beneath the first with the edge of the chisel directed downward and inward through the bark. Now press one of the sharpened ends of the twig firmly into the lower incision and, bending the twig, spring the other end into the incision above. Such twigs should be placed at intervals of about an inch apart as far around the tree as the wound extends. If the incisions have been made true and the twigs are just the right length they

will be firm and will require no tying. The application of grafting wax at the points where the twigs enter the tree completes the operation. Fig. 2 shows the appearance of the tree when the task is completed except for the waxing. In this, as in all grafting operations, the success depends largely on having the parts which it is desired to unite press strongly together so it is important that the twigs used be quite stiff and springy and that they be cut to just the right length to fit the incisions. The vigor of the tree is also an important factor and it is not advisable to try any method of treatment on trees which for any reason are



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METHODS OF BRIDGING OVER INJURY TO TREES.

Pen sketch adapted from Thomas by W. P. Wheeler.

making an unsatisfactory growth and are evidently in poor condition. Young trees which have been planted only a year or two will seldom pay for the trouble of operating and in such cases it is usually best to pull out the injured tree and replant. Even with the best of success a tree which has been injured and repaired will not grow as fast for a year or two as a similar uninjured one.

N. O. BOOTH, *Assistant Horticulturist.*

Geneva, N. Y., Mar. 25, 1902.

REPORT

OF

INSPECTION WORK.

W. H. Jordan, *Director.*

L. L. Van Slyke, *Chemist.*

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F. D. Fuller, *Assistant Chemist.*

Table of Contents.

REPORT OF ANALYSES OF COMMERCIAL FERTILIZERS FOR THE SPRING AND FALL OF 1902.*

L. L. VAN SLYKE AND W. H. ANDREWS.

SUMMARY.

(1) Samples Collected. During the year 1902, the Station collected 924 samples of commercial fertilizers, representing 446 different brands. Of these different brands 309 were complete fertilizers; of the others, 58 contained phosphoric acid and potash without nitrogen; 28 contained nitrogen and phosphoric acid without potash; 7 contained nitrogen only; 34 contained phosphoric acid alone; and 10 contained potash salts only.

(2) Nitrogen. The 309 brands of complete fertilizers contained nitrogen varying in amount from 0.68 to 8.97 per ct., and averaging 2.24 per ct. The average amount of nitrogen found by the Station analysis exceeded the average guaranteed amount by 0.32 per ct. the guaranteed average being 1.92 per ct. and the average found being 2.24 per ct.

In 281 brands of complete fertilizers, the amount of nitrogen found was equal to or above the guaranteed amount, the excess varying from 0.01 to 1.39 per ct., and averaging 0.37 per ct.

In 28 brands the nitrogen was below the guaranteed amount, the deficiency varying from 0.01 to 1.51 per ct., and averaging 0.19 per ct. In 26 cases the deficiency was less than 0.5 per ct.

The amount of water-soluble nitrogen varied from 0 to 5.72 per ct. and averaged 0.93 per ct.

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*Partial reprint of Bulletin No. 216.

(3) Available Phosphoric Acid. The 309 brands of complete fertilizers contained available phosphoric acid varying in amount from 1.72 to 12.00 per ct., and averaging 8.62 per ct. The average amount of available phosphoric acid found by the Station analysis exceeded the average guaranteed amount by 0.91 per ct., the guaranteed average being 7.71 per ct. and the average found being 8.62 per ct.

In 277 brands of complete fertilizers, the amount of available phosphoric acid found was equal to or above the amount guaranteed, the excess varying from 0.02 to 7.32 per ct. and averaging 1.11 per ct.

In 32 brands, the available phosphoric acid was below the guaranteed amount, the deficiency varying from 0.02 to 1.50 per ct. and averaging 0.31 per ct. In 25 cases the deficiency was below 0.5 per ct.

The amount of water-soluble phosphoric acid varied from 0 to 9.80 per ct. and averaged 5.46 per ct.

(4) Potash. The complete fertilizers contained potash varying in amount from 0.55 to 13.33 per ct., and averaging 4.67 per ct. The average amount of potash found by the Station analysis exceeded the average guaranteed amount by 0.22 per ct. the guaranteed average being 4.45 per ct., and the average found being 4.67 per ct.

In 222 brands of complete fertilizers, the amount of potash found was equal to or above the guaranteed amount, the excess varying from 0.01 to 4.04 per ct., and averaging 0.57 per ct.

In 87 brands, the potash was below the guaranteed amount, the deficiency varying from 0.01 to 4.45 per ct. and averaging 0.48 per ct. In 57 of these cases, the deficiency was less than 0.5 per ct.

In 50 cases among the 309 brands of complete fertilizers the potash was contained in the form of sulphate free from an excess of chlorides.

(5) The retail selling price of the complete fertilizers varied from $16 to $44 a ton and averaged $26.14. The retail cost of the separate ingredients unmixed averaged $20.76, or $5.38 less than the selling price.

INTRODUCTION.

NUMBER AND KINDS OF FERTILIZERS COLLECTED.

During the year 1902, the Station's collecting agents visited 199 towns between April 2 and July 31, obtaining 924 samples of commercial fertilizers. These samples represent 446 different brands, the product of 51 different manufacturers, each manufacturer being represented by from one to 174 brands.

The subjoined tabulated statement indicates the different classes included in the collection.

CLASSES OF FERTILIZERS COLLECTED.

Brands containing only nitrogen	Brands containing only phosphoric acid.	Brands containing only potash.	Brands containing nitrogen and phosphoric acid without potash.	Brands containing phosphoric acid potash without nitrogen.	Brands of complete fertilizers.
7	34	10	28	58	309

COMPOSITION OF FERTILIZERS COLLECTED.

The following tabulated statement shows the average composition of the complete fertilizers collected during the year, together with a comparison of the guaranteed composition and that found by analysis.

AVERAGE COMPOSITION OF COMPLETE FERTILIZERS COLLECTED.

	PER CENT GUARANTEED.			PER CENT FOUND.			Average per ct. found above guarantee.
	Lowest.	Highest.	Average.	Lowest.	Highest.	Average.	
Nitrogen	0.41	8.23	1.92	0.68	8.97	2.24	0.32
Available phosphoric acid	1.50	12.00	7.71	1.72	12.00	8.62	0.91
Insoluble phosphoric acid	——	——	——	0.01	5.84	2.14	——
Potash	1.00	11.00	4.45	0.55	13.33	4.67	0.22
Water-soluble nitrogen	——	——	——	0.00	5.72	0.93	——
Water-soluble phosphoric acid	——	——	——	0.00	9.80	5.46	——

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

The trade-values in the following schedule have been agreed upon by the Experiment Stations of Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Vermont, as a result of study of the prices actually prevailing in the large markets of these states.

These trade-values represent, as nearly as can be estimated, the average prices at which, during the six months preceding March, the respective ingredients, *in the form of unmixed raw materials,* could be bought at retail for cash in our large markets. These prices also correspond (except in case of available phosphoric acid) to the average wholesale prices for the six months preceding March, plus about 20 per ct., in case of goods for which there are wholesale quotations.

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

	1902. Cts. per pound.
Nitrogen in ammonia salts	16½
Nitrogen in nitrates	15
Organic nitrogen in dry and fine-ground fish, meat and blood, and mixed fertilizers	16½
Organic nitrogen in fine-ground bone and tankage	16
Organic nitrogen in coarse bone and tankage	12
Phosphoric acid, water-soluble	5
Phosphoric acid, citrate-soluble	4½
Phosphoric acid, in fine-ground fish, bone and tankage	4
Phosphoric acid, in coarse fish, bone and tankage	3
Phosphoric acid in mixed fertilizers, insoluble in ammonium citrate and water	2
Potash as high-grade sulphate, in forms free from muriates (chlorides), in ashes, etc.	5
Potash in muriate	4¼

COMPARISON OF SELLING PRICE AND COMMERCIAL VALUATION.

Giving to the different constituents the values assigned in the schedule for mixed fertilizers, 16½ cents a pound for nitrogen, 5 cents a pound for water-soluble phosphoric acid, 4½ cents a pound for citrate-soluble phosphoric acid, 2 cents a pound for insoluble phosphoric acid, and 4½ cents a pound for potash, we can calculate the commercial valuation, or the price at which the separate unmixed materials contained in one ton of fertilizer, having the composition indicated in the preceding table, could be purchased for cash at retail at the seaboard. Knowing the retail prices at which these goods were offered for sale, we can also readily estimate the difference between the actual selling price of the mixed goods and the retail cash cost of the unmixed materials; the difference covers the cost of mixing, freight, profits, etc. We present these data in the following table:

COMMERCIAL VALUATION AND SELLING PRICE OF COMPLETE FERTILIZERS.

Commercial Valuation of Complete Fertilizers.	Selling Price of One Ton of Complete Fertilizer.			Average increased cost of mixed materials over unmixed materials for one ton.
Average.	Lowest.	Highest.	Average.	
$20 76	$16 00	$44 00	$26 14	$5 38

COST OF ONE POUND OF PLANT-FOOD IN FERTILIZERS AS PURCHASED BY CONSUMERS.

In the table below we present figures showing the average cost to the purchaser of one pound of plant-food in different forms in mixed fertilizers.

AVERAGE COST OF ONE POUND OF PLANT-FOOD TO CONSUMERS IN MIXED FERTILIZERS.

Nitrogen	20.8 cents.
Phosphoric acid (available)	6.1 cents.
Potash	5.7 cents.

NEW FERTILIZER LAW.

The State legislature amended the fertilizer law in 1899 and attention is called to the principal changes that affect manufacturers and dealers.

(1) All fertilizers selling for *five* dollars or more per ton come under the law.

(2) Every manufacturer, importer, dealer or agent must pay a license fee amounting to *twenty* dollars a year for each separate brand or kind of fertilizer or fertilizing material.

(3) Statements of guarantee analysis, etc., are to be filed and license fees paid *during December* each year covering the goods to be sold during the year following.

LIST OF MANUFACTURERS WHO HAVE PAID LICENSE FEES AND FILED STATEMENTS AS REQUIRED BY LAW FOR 1902.

Manufacturers, to the number of 71, have, since the first of December, 1901, paid license fees and filed statements in compliance with the provisions of the law. Of these there are 29 firms whose places of business are located outside of New York State. These 71 manufacturers put on the market 548 different brands of fertilizers, including mixed and unmixed goods. The new fertilizer law has proved very efficient in diminishing the number of brands of fertilizers offered for sale. In 1899 there were offered for sale 2,268 brands as against 548 in 1902. Moreover, the results of analysis show higher average composition in 1902 than in 1899. In some cases manufacturers who offered twenty brands for sale in 1899 now offer only one.

NAMES AND ADDRESSES OF MANUFACTURERS.

	Number of brands reported.
The Abbott-Martin Rendering Co., Columbus, Ohio......	4
The American Agricultural Chemical Co., 26 Broadway, New York city	212
Armour Fertilizer Works, 205 La Salle street, Chicago, Ill..	18
E. Aspinall, 100 Beekman street, New York city........	2
A. M. Baker & Son, Mt. Morris, N. Y..................	1
Berg Co., Station E, Philadelphia, Pa..................	3
Berkshire Fertilizer Co., Bridgeport, Conn.............	3
Bowker Fertilizer Co., 43 Chatham street, Boston, Mass.,	26
Bradley & Green Fertilizer Co., Ninth and Girard avenues, Philadelphia, Pa..............................	3
Bucyrus Fertilizer Co., Bucyrus, Ohio..................	2
J. P. Butts, Oneonta, N. Y............................	3
Chicago Fertilizer Co., Security building, Chicago, Ill....	5
E. Frank Coe Co., 135 Front street, New York city......	28
Peter Cooper's Glue Factory, 13 Burling Slip, New York city	1
Eagle Guano Co., 19 Liberty street, New York city......	1
Eastern Chemical Co., 620 Atlantic avenue, Boston, Mass.,	1
Farmers Fertilizer and Chemical Co., Syracuse, N. Y....	6
Louis Fechter, East Buffalo, N. Y......................	1
John Finster, Rome, N. Y.............................	1
Henry Fitchard, Minetto, N. Y.........................	1
George B. Forrester, 159 Front street, New York city....	2
Henry S. Foster, Tonawanda, N. Y.....................	1
Charles E. Giles, Apalachin, N. Y......................	1
Griffith & Boyd, 9 South Gay street, Baltimore, Md......	10
John Haefele, Delaware avenue, Albany, N. Y..........	1
Hammond's Slug-Shot Works, Fishkill Landing, N. Y....	1
F. E. Hancock, Walkerton, Ontario, Canada............	1
S. M. Hess & Bro., Fourth and Chestnut streets, Philadelphia, Pa..	10
International Seed Co., Rochester, N. Y...............	4

	Number of brands reported.
Jarecki Chemical Co., Sandusky, Ohio	9
Lackawanna Fertilizer and Chemical Co., Moosic, Pa.	10
Listers' Agricultural Chemical Works, Newark, N. J.	18
Joseph Lister, Chicago, Ill.	1
Lonergan & Livingston, Albany, N. Y.	1
Lowell Fertilizer Co., Boston, Mass.	7
F. Ludlam, 108 Water street, New York city	7
Mapes Formula and Peruvian Guano Co., 143 Liberty street, New York city	22
Maxson & Starin, Cortland, N. Y.	2
Michigan Carbon Works, Detroit, Mich.	6
Miller Fertilizer Co., 411 East Pratt street, Baltimore, Md.	1
L. Mittenmaier & Son, Rome, N. Y.	5
George L. Munroe, Oswego, N. Y.	1
Nassau Fertilizer Co., 5 Beaver street, New York city	10
National Fertilizer Co., Bridgeport, Conn.	2
Newburgh Rendering Co., Newburgh, N. Y.	1
William C. Newport Co., 407 Drexel Bldg., Philadelphia, Pa.	5
Norton & Colson, Byron, N. Y.	7
A. W. Perkins & Co., Rutland, Vt.	1
A. Peterson, Penfield, N. Y.	1
William W. Phipps, Albion, N. Y.	3
Piedmont-Mt. Airy Guano Co., 109 Commerce street, Baltimore, Md.	5
B. J. Pine, East Williston, N. Y.	2
R. H. Pollock, 51 S. Gay street, Baltimore, Md.	6
R. C. Reeves, 187 Water street, New York city	1
George Ripperger, Long Island city	1
Riverside Acid Works, Warren, Pa.	2
Rochester Fertilizer Works, Rochester, N. Y.	10
Sanderson Fertilizer Co., New Haven, Conn.	2
Schaal-Shelden Fertilizer Co., Erie, Pa.	12
Charles C. Schader, Martville, N. Y.	1

	Number of brands reported.
Charles D. Smith, 2 Borden avenue, Long Island city....	1
Elmer E. Smith, Wurtsboro, N. Y.....................	1
Frank B. Smith, Columbiaville, N. Y....................	1
H. Stappenbeck, Utica, N. Y...........................	3
Syracuse Reduction Co., Syracuse, N. Y................	7
I. P. Thomas & Son Co., 2 South Delaware avenue, Philadelphia, Pa..	7
J. M. Thorburn & Co., 36 Cortlandt street, New York city,	3
J. E. Tygert Co., 42 South Delaware avenue, Philadelphia, Pa..	3
W. E. Whann, William Penn, Pa........................	3
R. White, Arlington, N. Y..............................	1
Wilcox Fertilizer Works, Mystic, Conn.................	1

TERMS USED IN STATING RESULTS OF ANALYSIS.

In the tables following, the terms used to express results of analysis are self-explanatory for the most part. Attention is called, however, to "water-soluble" phosphoric acid and nitrogen, and to "potash present in the form of sulphate."

While manufacturers are required to guarantee only the amount of available phosphoric acid (water-soluble plus reverted or citrate-soluble), yet it seems desirable that consumers should know what proportion of the available is water-soluble. The amounts of available phosphoric acid being equal, one would commonly choose by preference a fertilizer containing the larger amount of water-soluble phosphoric acid.

The water-soluble nitrogen includes nitrogen present in the form of ammonia salts and nitrates together with that present in small amounts of soluble organic matter. It should not be inferred that water-soluble nitrogen is of more value than the rest. It is of course more readily available, so far as it consists of nitrates, but it must be remembered that nitrogen in this form leaches and is lost to plants more readily than nitrogen in other forms.

When the potash is present in the form of sulphate, this is indicated. The figures given for potash in these tables represent always actual potash (K_2O). If, when potash is present as sulphate, it is desired to know how much sulphate of potash is present in the fertilizer, then simply multiply the figure given in the Station analysis by 1.85.

For extended details regarding the value of different forms of plant-food, the reader is referred to Bulletin No. 94.

[The analyses of samples collected are omitted from this Report, as they cease to have value before the Report can be distributed.—DIRECTOR.]

INSPECTION OF FEEDING STUFFS.*

W. H. Jordan, C. G. Jenter and F. D. Fuller.

SUMMARY.

The report given herewith of the inspection of feeding stuffs comprises the following:

(1) List of brands licensed in the State of New York for the year 1902:

(2) Analyses of samples collected in 1902.

(3) Comments on the facts shown by the inspection.

FEEDING STUFFS LICENSED IN 1902.

During the present year eighty-five manufacturers or jobbers have registered the guaranteed composition and paid the license fee on one hundred and twenty-nine brands of feeding stuffs to be placed on sale in the State of New York.

The brands named in the following list may be handled by dealers during the present year, without fear of violating the State law, as far as selling unlicensed goods is concerned, and may be purchased by the farmer with the assurance, excepting in infrequent cases, that the goods contain the amounts of protein and fat, within reasonable limits, guaranteed by the manufacturer of the goods.

*Reprint of Bulletin No. 217.

TABLE I.— MANUFACTURERS AND IMPORTERS WHO HAVE COMPLIED WITH THE NEW YORK FEEDING STUFFS LAW FOR THE YEAR 1902, WITH A LIST OF BRANDS SO GUARANTEED AND THE GUARANTEES.

License No.	Manufacturer or Jobber.		Name of Feed.	Guaranteed.	
	Name.	Address.		Protein.	Fat.
				Per ct.	Per ct.
213	Acme Milling Co.	Olean	Acme feed	8.50	4.50
232	Adikes, J.,& T	Jamaica	Ground feed	8.75	3.0
218	American Cereal Co., The	Chicago, Ill	Quaker dairy feed	14.0	3.5
	American Cereal Co., The	Chicago, Ill	Victor corn and oat feed	9.0	4.0
	American Cereal Co., The	Chicago, Ill	Schumacher's stock food	13.0	5.0
	American Cereal Co., The	Chicago, Ill	Corn, oats and barley feed	13.0	5.0
	American Cereal Co., The	Chicago, Ill	Buckeye wheat feed	17.75	4.7
	American Cereal Co., The	Chicago, Ill	Vim oat feed	7.5	2.75
	American Cereal Co., The	Chicago, Ill	American poultry food	14.0	4.5
197	American Cotton Oil Co., The	New York	"Prime" cottonseed meal	43.0	9.0
239	American Linseed Co.	New York	Oil meal, O. P	32—36	5—7
178	American Milling Co	Chicago, Ill	Sucrene dairy feed	16.5	3.5
246	American Spirits Mfg. Co	Peoria, Ill	Manhattan gluten feed	31.8-36.2	10.8-11.8
233	Armour Fertilizer Works, The	Chicago, Ill	Meat meal	65—68	12—14
	Armour Fertilizer Works, The	Chicago, Ill	Meat and bone	60—62	10—12
	Armour Fertilizer Works, The	Chicago, Ill	Blood meal	85—87	2—3
	Armour Fertilizer Works, The	Chicago, Ill	Poultry bone	24—26	5—6
192	Atlas Feed & Milling Co	Peoria, Ill	Atlas gluten meal	35.0	12.5
248	Bagley, G. A.	Peekskill	Mixed feed	12.44	4.65
205	Barwell, J. W	Waukegan, Ill	Blatchford's calf meal	26.0	5.0
208	Biles Co., The J. W	Cincinnati, O.	Biles' XXXX distiller's dried grains	33.0	11.0
	Biles Co., The J. W	Cincinnati, O.	Biles' XX distiller's dried grains	30.0	8.0
	Biles Co., The J. W	Cincinnati, O.	Biles' R. distillers dried grains	21.0	5.0
230	Bowker Fertilizer Co	Boston, Mass.	Animal meal	30.0	5.0
	Bowker Fertilizer Co	Boston, Mass.	Beef scraps	30.0	20.0

243	Brode, F. W., & Co.	Memphis, Tenn.	F. W. Brode & Co.'s "Owl" cottonseed meal	43.0	9.0
202	Brooks-Griffiths Co.	Minneapolis, Minn.	Royal mixed feed	16.61	5.48
252	Cassel, F. P.	Lansdale	F. P. C. chick manna	14.1	4.75
199	Cerealine Mfg. Co.	Indianapolis, Ind.	Cerealine feed, No. 1	7.88	5.99
	Cerealine Mfg. Co.	Indianapolis, Ind.	Cerealine feed, No. 2	10.82	8.03
179	Chapin & Co.	Buffalo	Green diamond homing food	11.0	8.0
	Chapin & Co.	Buffalo	Green diamond cottonseed meal	43.0	9.0
	Chapin & Co.	Buffalo	Green diamond linseed meal, O. P.	36.0	7.0
	Chapin & Co.	Buffalo	Gluten feed	28.0	3.0
258	Chester Mills	Buffalo	Chester stock food	9.5	4.0
247	Cleveland Milling Co.	Cleveland, O.	B chop	9.58	5.42
	Cleveland Milling Co.	Cleveland, O.	C chop	9.13	3.27
183	Commercial Milling Co.	Detroit, Mich.	Ground corn and oat feed provender	10.81	6.02
193	Crittenden, M. L.	Buffalo	Sterling provender	7.87	3.88
186	Crow & Williams	Ossining	Crow & Williams' mixed feed	9.0	4.0
177	Darling & Co.	Chicago, Ill.	Beef meal	55—65	10—15
	Darling & Co.	Chicago, Ill.	Beef scraps	55—65	15—20
240	Diamond Elevator & Milling Co.	Minneapolis, Minn.	Hominy feed	11.16	5.52
	Diamond Elevator & Milling Co.	Minneapolis, Minn.	"O. O." feed	10.51	5.75
236	Diamond Mills, The	Buffalo	C. & O. feed	9.44	4.78
253	Diamond Mills, The	Buffalo	Empire State cow feed	14.96	3.48
	Diamond Mills, The	Buffalo	Mixed feed	12.75	2.96
198	Ellicottville Milling Co.	Ellicottville	Chop feed	8.20	4.40
220	Elsworth, E., & Co.	Buffalo	De-Fi corn and oat feed	8.30	3.0
215	Empire Mills	Olean	Empire feed	7.63	2.97
184	Evans, C. H., & Sons	Hudson	Malt sprouts	28.44	0.46
222	Everett & Treadwell	Kingston	C. O. & W. feed	11.5	3.5
190	Finn's, H., Sons	Syracuse	Ground beef cracklings	45.88	20.4
267	Fuller-Page Co., The	Syracuse	Mohawk winter wheat feed	12.59	3.19
269	Fuller-Page Co., The	Syracuse	Mohawk dairy feed	35.60	12.40

TABLE I — (*Continued*).

License No.	Manufacturer or Jobber. Name.	Manufacturer or Jobber. Address.	NAME OF FEED.	Guaranteed. Protein.	Guaranteed. Fat.
				Per ct.	Per ct.
214	Glucose Sugar Refining Co	Chicago, Ill	Buffalo,Gluten feed	28.0	4.0
	Glucose Sugar Refining Co	Chicago, Ill	Chicago gluten meal	38.0	4.0
	Glucose Sugar Refining Co	Chicago, Ill	Germ oil meal	25.0	10.0
	Glucose Sugar Refining Co	Chicago, Ill	Fancy corn bran	14.0	4.0
180	Great Western Cereal Co., The	Chicago, Ill	"Boss" feed	8.27	3.64
	Great Western Cereal Co., The	Chicago, Ill	"Durham" feed	9.46	3.92
	Great Western Cereal Co., The	Chicago, Ill	"Royal" feed	8.25	4.14
	Great Western Cereal Co., The	Chicago, Ill	"Friends" feed	10.9	3.7
	Great Western Cereal Co., The	Chicago, Ill	Great Western dairy feed	12.25	3.2
259	Great Western Cereal Co., The	Chicago, Ill	Excelsior corn and oat feed	8.21	4.58
216	Harding, Geo. L	Binghamton	Ground beef scraps	42.0	30.0
	Harding, Geo. L	Binghamton	Harding's meat meal	49.0	19.0
249	Harding, Geo. L	Binghamton	Harding's unexcelled baby chick food	15.0	7.75
211	Hauenstein & Co	Buffalo	Linseed meal, O. P	37.82	7.5
234	Hayt, S. T	Corning	Corn and oats	10.0	4.0
221	H. O. Company, The	Buffalo	The H. O. Co.'s horse feed	12.0	4.5
	H. O. Company, The	Buffalo	The H. O. Co's dairy feed	18.0	4.5
	H. O. Company, The	Buffalo	The H. O. Co.'s poultry feed	17.0	5.5
255	Hodgman, W. S., & Co	Painted Post	Corn and oat chop feed	9.69	3.88
238	Hotton Bros	Portville	Common feed	8.38	4.85
209	Hudnut Co., The	Terre Haute, Ind	Hominy feed	12.85	8.52
261	Hudnut Co., The	Terre Haute, Ind	Maizelene feed	10.42	9.03
223	Husted Milling & Elevator Co	Buffalo	Monarch chop	10.4	3.27
	Husted Milling & Elevator Co	Buffalo	B chop	8.28	2.75
196	Illinois Sugar Refining Co	Pekin, Ill	Pekin gluten feed	27.7	3.5
187	Indianapolis Hominy Mills	Indianapolis, Ind	Hominy feed	11.62	8.48

200	Kellogg, Spencer	Buffalo	"S. K." oil meal	35.94	5.04
185	Kelloggs & Miller	Amsterdam	Linseed oil meal, O. P	36.7	7.83
191	Kentucky Milling Co., The	Henderson, Ky	"Jersey" mixed feed	11.56	3.65
219	Knickerbocker Milling and Grain Co	Albany	Champion feed	9.92	4.01
231	Lapham & Parks	Glens Falls	Common feed	7.5	3.5
244	Lowell Fertilizer Co	Boston, Mass	Bone and meat meal	50—60	10—15
264	Manitoba Mills Co	Cleveland, O	Mazie feed	26.24	7.06
181	Mann Bros. Co., The	Buffalo	Linseed oil meal	35.15	7.05
212	McCoy & Best	Peekskill	Evap. bone and meat meal	41.4	19.75
242	Merchants Distilling Co	Terre Haute, Ind	Merchants feed	31.3–35.0	12.7–12.9
203	Midland Linseed Oil Co	Minneapolis, Minn	Midland	32.5–37.5	5.5–8.5
251	Mueller, E. P	Milwaukee, Wis	Brewer's dried grains	24.86	5.69
	Mueller, E. P	Milwaukee, Wis	Barley sprouts	26.25	1.01
235	Nester, S. K	Geneva	Malt sprouts	25.0	2.0
272	New York Glucose Co	New York	Globe gluten feed	27.0	3.38
257	Newport Milling Co	Newport, Ind	Hominy feed	13.3	8.4
189	Norton & Co	Lockport, Ill	Standard oat feed	5.5	4.0
260	Norton & Co	Lockport, Ill	Anchor corn and oat feed	9.5	4.5
217	Oliver & Bolender	Olean	Chop feed	8.58	4.86
227	Oneonta Milling Co	Oneonta	Corn and oat provender	8.75	3.50
[illegible]	Oneonta Milling Co	Oneonta	Monarch horse feed	13.0	5.75
[illegible]	Oneonta Milling Co	Oneonta	"Arrow" corn and oat feed	9.0	3.75
263	Oneonta Milling Co	Oneonta	Special gluten	14.0	4.0
206	Patent Cereals Co., The	Geneva	Hominy feed	11.46	9.3
201	Pfeffer Milling Co	Lebanon, Ill	P. M. Co's bulk hominy feed	11.57	9.93
241	Pope, Chas., Glucose Co	Chicago, Ill	Cream gluten meal	38—40	2.5–3.0
	Pope, Chas., Glucose Co	Chicago, Ill	Corn bran	9—10	1.5–2.0
204	Pratt Cereal Mill Co	Decatur, Ill	Ground hominy feed	11.83	9.18
262	Rankin, M. G., & Co	Milwaukee, Wis	Jersey malt sprouts	25.0	2.5
266	Rankin, M. G., & Co	Milwaukee, Wis	Durham dried grains	25.0	7.0
228	Romaine, DeWitt	New York	Boiled beef and bone	45.0	15.0

TABLE I — (*Concluded*).

License No.	Manufacturer or Jobber.		Name of Feed.	Guaranteed.	
	Name.	Address.		Protein.	Fat.
				Per ct.	*Per ct.*
268	Rudolph & Huber	Poughkeepsie	Star five cent horse food	10.75	5.4
188	Shellabarger Mill and Elevator Co	Decatur, Ill	Shellabarger's hominy feed	11.14	9.02
250	Smith, A. V	Marcellus Falls	Barley feed	14.8	3.4
265	Stanton, H. M	Schenectady	Ground scraps	50.0	9.0
226	Staples, A. S	Rondout	Arcade mills mixed feed	10.42	5.86
224	Streeter, L. L., & Sons	Johnstown	Common feed	8.78	5.23
182	Suffern, Hunt & Co	Decatur, Ill	Hominy feed	11.02	7.84
237	Terwilliger, C. A	Niagara Falls	Niagara chop	10.42	4.83
194	Toledo Elevator Co., The	Toledo, O	Star brand feed	8.85	5.83
195	Toledo Elevator Co., The	Toledo, O	Hominy feed	10.93	7.05
207	Union Linseed Co	Troy	Cow brand oil meal	22.09	6.32
210	U. S. Frumentum Co	Detroit, Mich	Frumentum hominy feed	11.63	8.66
225	U. S. Sugar Refinery	Chicago, Ill	Waukegan gluten feed	27.38	3.39
229	Victor Mills	Springville	Golden chop	9.17	5.84
256	Wallacc, L. R	Middletown	Mapes balanced ration for poultry	14.0	4.5
254	Waller, A., & Co	Henderson, Ky	Blue grass mixed feed	12.59	3.19
245	Wright, M. M., & Co	Danville, Ill	Wright's hominy feed	10.93	8.0

The list of licensed brands may be classified as follows:

Cottonseed meal	3	brands.
Linseed meal	8	"
Gluten meal	4	"
Gluten feed	7	"
Germ oil meal	1	"
Distillery grains	5	"
Brewer's grains	2	"
Malt sprouts	4	"
Hominy feed	16	"
Corn bran	2	"
Meat and bone meal	15	"
Proprietary or mixed feeds	62	"
Total	129	brands.

ANALYSES OF SAMPLES COLLECTED DURING 1902.

The following table (II) shows the analyses of the samples of feeding stuffs collected in various parts of the State during 1902. The percentages of protein and fat found are given for comparison with the guarantees. In the case of those samples where it was reasonable to suspect the presence of oat hulls or some other inferior ingredients, the proportion of crude fiber was determined. As a matter of interest the retail selling prices are given as stated by the dealers from whose stock the samples were taken.

TABLE II.— SAMPLES OF FEEDING

Collection No.	NAME AND ADDRESS OF MANUFACTURER OR JOBBER.	Sampled at
424	American Cotton Oil Co., Huntsville, Ala.	Poughkeepsie, W. S. Reynolds & Co.
473	Chapin & Co., Buffalo	Kingston, Wilson & Wolven
412	Humphreys, Goodwin & Co., Memphis, Tenn.	Albany, George Drew
503	Humphreys, Goodwin & Co., Memphis, Tenn.	Utica, G. W. Head Co.
478	Leder Oil Co., Demopolis, Ala.	Kingston, Everett & Treadwell
399	Robinson, George B., Jr., New York	Albany, Barber & Bennett
445	Travis, W. S., New York	New York, Fisk, Clark & Allen
455	Travis, W. S. ,New York	Long Island City, Thomas Morgan Mill
493	Williams, E. B., & Co., Memphis, Tenn.	Amsterdam, W. N. Carpenter
387	American Linseed Co., Chicago, Ill.	Albany, F. Reuter
420	American Linseed Co., Chicago, Ill.	Poughkeepsie, Wm. S. Reynolds & Co.
458	American Linseed Co., Chicago, Ill.	New York, W. H. Payne & Son
504	Falls, J. C., & Co., Memphis, Tenn.	Utica, G. W. Head Co.
398	Kelloggs & Miller, Amsterdam	Albany, Barber & Bennett
451	Kelloggs & Miller, Amsterdam	New York, John E. Connelly & Co.
490	Kelloggs & Miller, Amsterdam	Amsterdam, Kelloggs & Miller
523	Mann Bros., Buffalo	Naples, J. E. Lyon
404	Midland Linseed Co., Minneapolis, Minn.	Albany, Mahar Bros.
444	Midland Linseed Co., Minneapolis, Minn.	New York, Fisk, Clark & Allen
481	Union Linseed Co., Troy	Rondout, A. S. Staples
475	Glucose Sugar Refining Co., Chicago, Ill.	Kingston, Wilson & Wolven
518	Fuller-Page Co., Syracuse	Philadelphia, Wilson Bros.
495	Dean, C. R., Owego	Amsterdam, W. N. Carpenter
403	Glucose Sugar Refining Co., Chicago, Ill.	Albany, H. S. Bell & Co.
411	Illinois Sugar Refining Co., Pekin, Ill.	Albany, George Drew
500	Sull-Franke Grain Co., Waukegan, Ill.	Utica, Ogden & Clark
391	National Starch Co., Glen Cove, N. J.	Albany, J. H. Peters' Sons
483	U. S. Sugar Refinery, Waukegan, Ill.	Rondout, A. S. Staples
474	Glucose Sugar Refining Co., Chicago, Ill.	Kingston, Wilson & Wolven
498	Biles Co., The J. W,. Cincinnati, O.	Utica, Ogden & Clark
413	Beakes, Albany	Albany, George Drew
468	Chapin & Co., Buffalo	Kingston, Wilson & Wolven
487	Clapp, A. J., New York	Rondout, A. S. Staples
499	Cox & Co., Boston, Mass.	Utica, Ogden & Clarke
414	Evans & Sons, Hudson	Hudson, Evans & Sons
430	Nester, S. K., Geneva	Peekskill, C. S. Horton & Sons
426	Reynolds & Co., Poughkeepsie	Peekskill, G. W. Bagley & Son
419	Robinson, G. B., Jr., New York	Hudson, Dunning & Bogardus
402	Banner Food Co., New York	Albany, H. S. Bell & Co.
492	Barwell, J. W., Waukegan, Ill.	Amsterdam, W. N. Carpenter
501	Barwell, J. W., Waukegan, Ill.	Utica, Ogden & Clark
405	H. O. Company, The, Buffalo	Albany, Mahar Bros.
390	H. O. Company, The, Buffalo	Albany, J. H. Peters' Sons
432	H. O. Company, The, Buffalo	Peekskill, C. S. Horton & Sons
407	American Cereal Co., The, Chicago, Ill.	Albany, George Drew
418	American Cereal Co., The, Chicago, Ill.	Hudson, Downing & Bogardus
429	American Cereal Co., The, Chicago, Ill.	Poughkeepsie, G. W. Bagley & Son.
401	Kenwood Mill, Kenwood	Albany, H. S. Bell & Co.
520	American Cereal Co., The, Chicago, Ill.	Almond, C. W. Sisson
509	Amos, Jacob, Syracuse	Syracuse, Jacob Amos
441	Hecker-Jones Mill Co., New York	New York, Hecker-Jones Mill Co.
409	Imperial Mills Co., Duluth, Minn.	Albany, George Drew
472	Imperial Mills Co., Duluth, Minn	Kingston, Wilson & Wolven
506	Imperial Mills Co., Duluth Minn.	Utica, G. W. Head Co.
408	Stone, R. C., Milling Co., Springfield, Mo.	Albany, George Drew
479	Ustman, William, Mill Co., Superior, Wis.	Kingston, Everett & Treadwell
446	Ustman, William, Mill Co., Superior, Wis.	New York, Fisk, Clark & Allen
460	Long Dock Mill & Elevator Co., Jersey City, N. J.	New York, Long Dock Mill & Elevator Co.
386	Pillsbury, Minneapolis, Minn.	Albany, F. Reuter
466	Reed. I. H., New York	Brooklyn, Brooklyn Elevator and Mill Co.
452	Clapp, A. Jerome, New York	New York, J. E. Connelly
449	Clapp, A. Jerome, New York	New York, H. Ingersoll
480	M. & M. M. Co., Rochester	Kingston, Everett & Treadwell

STUFFS COLLECTED DURING 1902.

Name of feed.	Protein.		Fat.		Crude fibe found.	Price per ton.	Collection No.
	Found.	Guaranteed.	Found.	Guaranteed.			
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.		
Cotton seed meal, prime	44.7	43.0	10.9	9.0		$30 00	424
Cotton seed meal, green diamond	45.1	43.0	9.3	9.0		28 00	473
[1]Cotton seed meal, Dixie brand	46.5	43.0	12.1	9.0		30 00	412
[1]Cotton seed meal, Dixie Brand	45.3	43.0	7.9	9.0		28 00	503
[1]Cotton seed meal	43.8	43.0	7.1	9.0		30 00	478
[1]Cotton seed meal	40.7	43.0	11.3	9.0			399
[1]Cotton seed meal	49.1		10.5			30 00	445
[1]Cotton seed meal	45.1		9.4			32 00	455
[1]Cotton seed meal, Daisy brand	46.7	43.0	9.9	9.0		32 00	493
Oil meal, O. P.	37.8	32–36	8.7	5.7		34 00	387
Oil meal, O. P.	36.4	32–36	8.6	5.7		35 00	420
Oil meal, O. P.	38.8	32–36	6.6	5.7		34 00	458
[1]Linseed meal, square	29.8	33.5	6.4	7.5		30 00	504
Oil meal, pure, O. P.	37.5	36.70	8.4	7.83			398
Oil meal, pure, O. P.	38.1	36.70	9.1	7.83		37 00	451
Oil meal, pure, O. P.	37.4	36.70	8.6	7.83		29 00	490
Oil meal, pure, O. P.	38.8	35.15	7.0	7.05			523
Linseed cake, ground, O. P.	36.9	32.5-37.5	7.7	5.5–8.5			404
Linseed meal, Midland	36.7	32.5-37.5	9.2	5.5–8.5		34 00	444
Oil meal, cow brand	31.6	22.09	6.6	6.32		36 00	481
Gluten meal	38.1	38.0	2.9	4.0		29 00	475
Gluten stock feed, Manhattan	39.8	36.22	11.5	11.70		27 00	518
Gluten feed, Buffalo	28.7	28.0	3.5	4.0		26 00	495
Gluten feed, Buffalo	29.3	28.0	3.7	4.0		27 00	403
Gluten feed, Pekin	28.1	27.7	5.0	3.5		28 00	411
[1]Gluten feed	26.8	27.38	4.7	3.39		25 00	500
[1]Gluten feed	24.1	22.9	2.7	2.3		28 00	391
Gluten feed, Waukegan	27.5	27.38	2.9	3.39		26 00	483
Germ oil meal	25.5	25.0	8.7	10.0			474
Distiller's dried grains, Biles' XXXX,	38.6	33.0	13.7	11.0		25 00	498
[1]Barley sprouts	28.2		4.4			22 00	413
[1]Malt sprouts	26.6		1.6			22 00	468
[1]Malt sprouts	28.6		2.0			22 00	487
[1]Malt sprouts	29.1		2.3				499
Malt sprouts	32.5	28.44	4.1	0.46		20 00	414
Malt sprouts	28.4	25.0	2.8	2.0		20 00	430
[1]Malt sprouts	28.1	23.48	2.7	1.68		20 00	426
[1]Malt sprouts	29.4		4.8			22 00	419
[1]Banner stock food	29.1	25.0	6.6	5.0		160 00	402
[1]Blatchford's sugar and oil meal	30.1	28.25	10.0	11.25		70 00	492
Blatchford's calf meal	25.9	26.0	4.6	5.0		70 00	501
H. O. Co.'s dairy feed	19.9	18.0	4.6	4.5	11.4	30 00	405
H. O. Co.'s horse feed	14.3	12.0	5.6	4.5	8.9	30 00	390
H. O. Co.'s. horse feed	13.9	12.0	5.2	4.5	8.8	31 00	432
Quaker dairy feed	15.6	14.0	3.8	3.5	15.1	26 00	407
Quaker dairy feed	15.2	14.0	5.6	3.5	15.2	25 00	418
Quaker dairy feed	18.6	14.0	5.8	3.5	13.7	24 00	429
Rye feed	16.8		3.5			24 00	401
Wheat feed, Buckeye	20.0	17.75	4.8	4.70			520
Mixed feed, bran, middlings and ships	19.2		5.2		7.2	17 00	509
Mixed feed, bran and middlings	21.1		ɔ.5		7.1	26 00	441
Mixed feed, "Boston," bran, middlings and low-grade flour	19.7		5.3		7.0	26 00	409
Mixed feed, "Boston," bran, middlings and low grade flour	19.6		5.0			25 00	472
Mixed feed, "Boston," bran, middlings and low-grade flour	19.9		5.0		6.9	24 00	506
Mixed feed, bran and middlings	19.6		4.2		6.6	26 00	408
Mixed feeed, bran and middlings	20.1		5.3			25 00	479
Middlings, No. 2 flour	18.3		2.2			28 00	446
Middlings, No. 1	17.3		3.4			26 66	460
Middlings, B	20.1		6.3			26 00	386
Middlings	20.9		4.6			26 00	466
Bran, Tuxedo	16.2		4.4			25 00	452
Bran	16.9		4.4			26 00	449
Bran	19.1		4.7			25 00	480

TABLE II

Collection No.	NAME AND ADDRESS OF MANUFACTURER OR JOBBER.	Sampled at
507	Voight Mill Co., Grand Rapids, Mich	Utica, G. W. Head & Co
512	Decatur Cereal Mill Co., Decatur, Ill	Saugerties, F. G. Phelps
427	Indianapolis Hominy Mills, Indianapolis, Ind	Peekskill, G. W. Bagley & Son
431	Indianapolis Hominy Mills, Indianapolis, Ind	Peekskill, C. S. Horton & Sons
417	Miami Maize Co., The, Toledo, Ohio	Hudson, Downing & Bogardus
421	Miami Maize Co., The, Toledo, Ohio	Poughkeepsie, W. S. Reynolds & Co.
471	Miami Maize Co., The, Toledo, Ohio	Kingston, Wilson & Wolven
485	Patent Cereals Co., The, Geneva	Rondout, A. S. Staples
456	Payne, W. H., & Son,, New York	New York, W. H. Payne & Son
462	Payne, W. H., & Son, New York	New York, Titus, Wells & Willets
511	Reynolds & Co., Poughkeepsie	West Coxsackie, Levi Bedell
470	Shellabarger Mill & Elevator Co., Decatur, Ill	Kinston, Wilson & Wolven
467	Simpson, Hendee & Co., New York	Kingston, C. F. Gray
435	Cerealine Mfg. Co., Indianapolis, Ind	Peekskill, Geo. F. Cooley
465	Brooklyn Elevator & Mill Co., Brooklyn	Brooklyn, Brooklyn Elevator & Mill Co
494	Huested Mill & Elevator Co., Buffalo	Amsterdam, McConnell, Cramer & Miller
448	Long Dock Mill & Elevator Co., Jersey City, N. J	New York, H. Ingersoll
461	Long Dock Mill & Elevator Co., Jersey City, N. J	New York, Long Dock Mill & Elevator Co
488	Huested Mill & Elevator Co., Buffalo	Amsterdam, Hill & Watson
459	Long Dock Mill & Elevator Co., Jersey City, N. J	New York, Long Dock Mill and vator Co
385	American Cereal Co., The, Chicago, Ill	Albany, F. Reuter
388	American Cereal Co., The, Chicago, Ill	Albany, J. H. Peters' Sons
524	American Cereal Co., The, Chicago, Ill	Almond, C. W. Sisson
397	Barber & Bennett, Albany	Albany, Barber & Bennett
464	Brooklyn Elevator and Milling Co., Brooklyn	Brooklyn, Brooklyn Elevator and Milling Co
396	Coonley, George W., Albany	Albany, George W. Coonley
395	Diamond Mills, Buffalo	Albany, Leonard & Co
521	Diamond Mills, Buffalo	Naples, J. E. Lyon
469	Elsworth & Co., Buffalo	Kingston, Wilson & Wolven
497	Elsworth & Co., Buffalo	Utica, Ogden & Clark
442	Fisk, Clark & Allen, New York	New York, Fisk, Clark & Allen
443	Fisk, Clark & Allen, New York	New York, Fisk, Clark & Allen
415	Great Western Cereal Co., The, Chicago, Ill	Hudson, Downing & Bogardus
416	Great Western Cereal Co., The, Chicago, Ill	Hudson, Downing & Bogardus
505	Head Co., G. W., Utica	Utica, G. W. Head Co
389	Heath, H. R., & Son, Fort Dodge, Ia	Albany, J. H. Peters' Sons
516	Herrick & Son, Watertown	Watertown, Herrick & Son
453	Morgan, Thomas, Mill, Long Island City	Long Island City, Thomas Morgan Mill
502	Ogden & Clark, Utica	Utica, Ogden & Clark
423	Oliver, David, Joliet, Ill	Poughkeepsie, W. S. Reynolds & Co.
519	Wilson Bros., Philadelphia	Philadelphia, Wilson Bros
514	Yousey, C. F., & Co., Lowville	Lowville, C. F. Yousey & Co
400	Oneonta Milling Co., Oneonta	Albany, H. S. Bell & Co
392	Oneonta Milling Co., Oneonta	Albany, J. H. Peters' Sons
477	Everett & Treadwell Kingston	Kingston, Everett & Treadwell
508	Amos, Jacob, Syracuse	Syracuse, Jacob Amos
517	Herrick & Son, Watertown	Watertown, Herrick & Son
484	Staples, A. S., Rondout	Rondout, A. S. Staples
510	Webster, G. W., & Son, Cortland	Cortland, G. W. Webster & Son
425	Bagley, G. W., & Son, Peekskill	Peekskill, G. W. Bagley & Son
457	Payne, W. H., & Son, New York	New York, W. H. Payne & Son
513	Yousey, C. F., & Co., Lowville	Lowville, C. F. Yousey & Co
394	American Cereal Co., Chicago, Ill	Albany, Righter & Son
410	American Cereal Co., Chicago, Ill	Albany, George Drew
463	Brooklyn Elevator & Milling Co., Brooklyn	Brooklyn, Brooklyn Elevator & Milling Co
476	Clapp, A. J., New York	Kingston, Wilson & Wolven
486	Great Western Cereal Co., Chicago, Ill	Rondout, A. S. Staples
447	Long Dock Mill & Elevator Co., Jersey City, N. J	New York, H. Ingersoll
454	Morgan, Thos., Mill, Long Island City	Long Island City, Thos. Morgan Mill
439	Adikes, J. & T., Jamaica	Jamaica, J. & T. Adikes
496	Husted Mill & Elevator Co., Buffalo	Amsterdam, McConnell, Cramer & Miller

—(*Continued*).

Name of feed.	Protein.		Fat.		Crude fibre found.	Price per ton.	Collection No.
	Found.	Guaranteed.	Found.	Guaranteed.			
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.		
Bran, winter wheat	17.3	......	4.1	......	7.4	$24 00	507
[1]Hominy feed	12.6	11.83	8.3	9.18	4.5	27 00	512
Hominy feed	11.9	11.62	9.2	8.48	4.4	29 00	427
Hominy feed	11.2	11.62	7.3	8.48	4.3	27 00	431
Hominy feed	10.9	10.93	8.6	7.05	7.5	29 00	417
Hominy feed	10.8	10.93	9.5	7.05	7.9	29 00	421
Hominy feed	11.1	10.93	6.8	7.05	6.9	28 00	471
Hominy feed	12.7	11.46	9.0	9.3	4.3	26 00	485
[1]Hominy feed	12.4	......	7.7	......	4.1	......	456
[1]Hominy feed	12.2	......	8.5	......	4.4	25 00	462
[1]Hominy feed	13.4	......	10.4	......	4.2	27 00	511
Hominy feed	11.3	11.14	6.6	9.02	8.0	28 00	470
[1]Hominy feed	12.7	......	9.2	......	4.2	28 00	467
Cerealine feed, No. 2	12.6	10.82	8.1	8.03	2.4	30 00	435
Corn meal	10.5	......	3.8	......	......	25 00	465
Corn meal	10.5	......	3.2	......	2.6	28 00	494
Corn meal	10.6	......	4.0	......	......	30 00	448
Corn meal	10.3	......	3.7	......	......	26 00	461
Corn and oats, half and half	12.1	......	3.6	......	3.4	32 00	488
Corn and oats, half and half	12.5	......	5.1	......	4.6	28 00	459
Corn and oat feed, Victor	10.9	9.0	5.1	4.0	11.7	27 00	385
Corn and oat feed, Victor	11.1	9.0	4.6	4 0	9.4	27 00	388
Corn and oat feed, Victor	10.8	9.0	4.5	4.0	10.7	......	524
[1]Corn and oat feed,	10.2	......	3.4	......	10.0	28 00	397
Corn and oat feed	12.4	......	4.0	......	5.4	29 00	464
[1]Corn and oat feed	11.9	......	3.8	......	7.8	28 00	396
Corn and oat feed	9.6	9.44	4.2	4.78	10.4	27 00	395
Corn and oat feed	9.3	9.44	3.5	4.78	12.1	......	521
Corn and oat feed, De-Fi	10.1	8.3	3.0	3.0	13.4	24 00	469
Corn and oat feed, De-Fi	10.2	8.3	3.4	3.0	......	25 00	497
Corn and oat feed, No. 1	11.9	......	3.8	......	5.1	30 00	442
Corn and oat feed, No. 2	9.9	......	3.6	......	5.3	29 00	443
Corn and oat feed, Durham	8.1	9.46	3.3	3.92	14.5	28 00	415
Corn and oat feed, Boss	7.8	8.27	3.3	3.64	15.9	28 00	416
Corn and oat feed	10.9	......	4.4	......	4.2	30 00	505
[1]Corn and oat feed, Yankee	9.1	8.96	3.1	4.33	14.4	24 00	389
Corn and oat feed	12.9	......	4.3	......	6.0	32 00	516
Corn and oat feed	11.2	......	4.4	......	4.8	27 40	453
Corn and oat feed	12.7	......	4.0	......	5.9	30 00	502
[2]Corn and oat feed, Durham	9.0	9.46	2.6	3.92	13.9	27 00	423
Corn and oat feed	13.0	......	4.7	......	9 6	30 00	519
Corn and oat feed	13.3	......	4.4	......	3.6	31 00	514
Corn and oat feed, chop feed	8.7	9.0	4.6	3.75	15.7	28 00	400
Corn and oat feed, provender	8.7	8.75	3.6	3.50	12.0	......	392
Corn, oats and wheat feed	13.0	11.5	4.2	3.5	7.1	28 00	477
[1]Corn, oats and middlings	12.1	......	2.8	......	4.7	26 00	508
[1]Corn, oats and ships	14.3	......	4.8	......	5.3	29 00	517
Corn, oats and rye	13.1	......	3.6	......	4.5	32 00	484
Corn, oats and rye	10.6	......	3.6	......	7.3	20 00	510
Corn, oats, rye, hominy, and middlings	16.9	12.44	4.7	4.65	4.7	29 00	425
[1]Corn, oats, hominy and oat hulls	10.4	......	4.2	......	6.4	32 00	457
[1]Corn, bran and middlings	15.2	......	4.4	......	......	26 00	513
[1]Oat feed, X	9.1	6.30	3.2	2.38	22.2	22 00	394
Oat feed, Vim	8.0	7.5	2.4	2.75	23.5	20 00	410
Oat feed	13.4	......	4.0	......	8.5	32 00	463
[1]Oat feed, golden	3.6	......	1.3	......	29.3	20 00	476
Oat feed, royal	6.1	8.25	2.1	4.14	25.0	......	486
Oat feed	14.9	......	4.6	......	7.7	30 00	447
Oat feed	13.1	......	5.6	......	8.4	34 40	454
Ground feed	9.5	8.75	3.5	3.00	......	18 00	439
Chop feed, B.	7.0	8.28	2.2	2.75	15.8	27 00	496

TABLE II

Collection No.	NAME AND ADDRESS OF MANUFACTURER OR JOBBER.	Sampled at
393	Knickerbocker Milling Co., Albany	Albany, Righter & Son
434	Murer, Alfred, Co., Milwaukee, Wis	Peekskill, George F. Cooley
491	Pillsbury-Washburne Flour Mills Co., Ltd., Minneapolis, Minn	Amsterdam, W. N. Carpenter
482	Staples, A. S. Rondout	Rondout, A. S. Staples
515	Waller, A., & Co., Henderson, Ky	Lowville, Louis Bush
377	American Cereal Co., Chicago, Ill	New York, Excelsior Wire & Poultry Supply Co
383	American Cereal Co., Chicago, Ill	New York, Cypher Incubator Co
376	H. O. Company, The, Buffalo	New York, Excelsior Wire & Poultry Supply Co
406	H. O. Company, The, Buffalo	Albany, Mahar Bros
380	Pineland Incubator Co., Jamesburg, N. J	New York, Excelsior Wire & Poultry Supply Co
440	Harding, George L., Binghamton	New York, Cornell Incubator Mfg. Co
384	Pratt Food Co., Philadelphia, Pa	New York, Cypher Incubator Co
382	Spratt's Patent, (Am.) Ltd., Newark, N. J	New York, Cypher Incubator Co
381	Star Incubator Co., Bound Brook, N. J	New York, Star Incubator Co
379	Bowker Fertilizer Co., New York	New York, Excelsior Wire & Poultry Supply Co
436	Darling & Co., Chicago, Ill	New York, Cypher Incubator Co
437	Darling & Co., Chicago, Ill	New York, Cypher Incubator Co
438	Harding, George L., Binghamton	New York, Cornell Incubator Mfg. Co
378	Smith & Romaine, New York	New York, Excelsior Wire & Poultry Supply Co

—(*Concluded*).

Name of feed.	Protein.		Fat.		Crude fiber found.	Price per ton.	Collection No.
	Found.	Guaranteed.	Found.	Guaranteed.			
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*		
Champion feed	12.5	9.92	3.9	4.01	8.5	$26 00	393
[1]Dick feed	16.4	14.0	4.6	3.0	9.9	30 00	434
Dairy feed	8.1	7.09	2.6	2.85	23.0	21 00	491
Arcade mixed feed, hominy, oat hulls and royal oat feed	8.3	10.42	4.3	5.86	15.3	25 00	482
Mixed feed, blue grass, wheat bran and ground corn cobs	14.8	12.59	4.1	3.19	11.5	23 00	515
Poultry food, American	15.3	14.0	6.7	4.5	4.7	30 00	377
Poultry food, American	15.2	14.0	6.5	4.5	4.8	40 00	383
Poultry food, H. O	19.9	17.0	6.3	5.5	4.6	35 00	376
Poultry food, H. O	20.8	17.0	5.3	5.5	4.1	40 00	406
[1]Chick food, Fidelity	15.6	20.47	3.9	3.68	2.5	55 00	380
Chick food, Baby	16.5	15.00	7.5	7.75	2.5	50 00	440
[1]Poultry food, Pratt's	16.8	....	7.9	....	7.7	....	384
[1]Poultry food, Spratt's patent	24.4	....	3.2	....	1.5	120 00	382
[1]Poultry food, Star, morning mash	8.8	....	1.6	....	2.4	25 00	381
Animal meal	39.8	30.0	9.7	5.0	......	35 00	379
Beef scraps, ground	65.2	55–65	15.7	15–20	......	40 00	436
Beef meal	64.6	55–65	10.7	10–15	......	40 00	437
Meat meal[2]	72.2	49.0	15.8	19.0	......	45 00	438
[3]Boiled beef and bone	49.4	45.0	17.3	15.0	......	34 00	378

[1]Not licensed in this state in 1902.
[2]Licensed by the Great Western Cereal Co.
[3]Licensed by De Witt Romaine.

The samples analyzed may be classified as follows:

TABLE III.— CLASSIFICATION OF SAMPLES ANALYZED.

	Samples.	Brands.	Samples unlicensed goods.
	No.	*No.*	*No.*
Cottonseed meal	9	7	5
Linseed meal	11	6	1
Gluten meal	2	2	....
Gluten feed	6	5	2
Germ oil meal	1	1	....
Distillery grains	1	1	....
Malt sprouts	8	8	6
Hominy feed	13	19	4
Mixed offals (bran and middlings)	17	5	....
Ground grains	6	5	....
Meat and bone meal	5	5	....
Proprietary or mixed feeds	64	54	16
Total	143	118	34

COMMENTS.

The previous table shows the following range of prices as stated by the retail dealers:

Cottonseed meal	\$28–\$32	per ton.
Linseed meal	29– 36	"
Gluten meal	27– 29	"
Gluten feed	25– 28	"
Malt sprouts	20– 22	"
Hominy feeds	26– 30	"
Wheat offals	17– 28	"
Meat and bone meal	34– 45	"
Proprietary or mixed feeds	18– 32	"

Although the list shows a large number of samples of unlicensed goods, almost half of the number falls upon the proprietary or mixed goods. More unlicensed samples of cottonseed meal, malt sprouts and hominy feeds seem to have been found in our markets than in the two former years.

It is gratifying to note that the discrepancies between the guarantees and the actual composition of the samples as analyzed are becoming less numerous from year to year. This may readily be seen from the following list:

TABLE IV.— SAMPLES FALLING BELOW GUARANTEES.

	In protein.	In fat.
	Per ct.	*Per ct.*
1900	50	30
1901	31	23
1902	11	21

Most of the discrepancies, during the past season, fall upon the unlicensed and proprietary goods, nearly all of the standard feeds being as good as indicated by the guarantee, in many cases even exceeding it.

As repeatedly shown in former bulletins, the sale and use as adulterants of such materials as oat hulls and corn cobs are a serious menace not only to the commercial reputation of the feeding stuff trade, but to the farmer's pocketbook. The attention of consumers is emphatically directed to certain brands of goods included in the above list of analyses.

A word of explanation, although a repetition of previous statements, is given in this connection. The percentage of crude fiber in oats is shown by tables of analyses to vary from 1.5 per ct. to 12.9 per ct., the average being 9.5 per ct., and in dent corn from 0.9 per ct. to 4.8 per ct., with an average of 2.2 per ct. If, then, a mixture is made of average corn and oats in equal parts, the percentage of fiber should approximate 5.8 per ct. If two-thirds corn and one-third oats, the average percentage of fiber would be 4.6 per ct. When, therefore, a mixture supposedly corn and oats, and which actually contains a considerable proportion of corn, shows 10 per ct. of fiber and upwards, it is reasonable to conclude that oat hulls or very inferior oats are present. Another indication of the presence of oat hulls in so-called corn and oat mixtures is a percentage of protein as low as 9 per ct. or below. To be sure some manufacturers are shrewd enough to introduce into their compounded goods enough of some highly nitrogenous material to bring the proportion of protein up to or above what pure corn and oats would contain, but this expedient in no way increases the value of the inferior ingredients present. The percentages

of protein and fat in a feeding stuff as so often urged, are only a partial measure of value. *The character of the carbohydrate portion must be considered,* and when oat hulls are present this part of the feed becomes more or less degraded.

The same line of reasoning may be applied to other feeding stuffs. Pure hominy feeds, according to several analyses made in the laboratory of this Station, contain less than 5 per ct. of fiber. It is noticeable that the samples of hominy feed shown in the foregoing table appear to be divided into classes, one containing the normal proportion of fiber, viz.: 4.1 per ct. to 4.5 per ct., and another in which the fiber varies from 6.9 per ct. to 8.0 per ct. The latter samples are somewhat inferior in appearance and show an abnormal proportion of fibrous material.

There is being sold in the State a class of goods made up chiefly of wheat bran, but containing an adulterant which in certain instances is corn cobs or some material equally inferior. To the uninitiated such mixtures appear to be pure wheat bran. It is significant, however, that these goods are sold under proprietary names and that the guarantee for protein is less than what pure bran contains. Buyers should be on the watch for commodities of this class.

The following table shows the samples to which it is well to apply the above considerations:

TABLE V.— BRANDS NEEDING SPECIAL CONSIDERATION.

No. sample.	MANUFACTURER.	Protein.	Fat.	Fiber.
	HOMINY FEEDS:	*Per ct.*	*Per ct.*	*Per ct.*
417	The Miami Maize Co., Toledo, O.	10.9	8.6	7.5
421	The Miami Maize Co., Toledo, O.	10.8	9.5	7.9
470	The Miami Maize Co., Toledo, O.	11.1	6.8	6.9
471	Shellabarger Mill & Elevator Co., Decatur, O.	11.3	6.6	8.0
	PROPRIETARY AND MIXED FEEDS:			
385	Victor Corn and Oat Feed	10.9	5.1	11.7
388	Victor Corn and Oat Feed	11.1	4.6	9.4
524	Victor Corn and Oat Feed	10.8	4.5	10.7
407	Quaker Dairy Feed	15.6	3.8	15.1
418	Quaker Dairy Feed	15.2	5.6	15.2
429	Quaker Dairy Feed	18.6	5.8	13.7
469	De-Fi Corn and Oat Feed	10.1	3	10.4
415	Durham Feed	8.1	3.3	14.5
423	Durham Feed	9	2.6	13.9
416	Boss Feed	7.8	3.3	15.9
389	Yankee Feed	9.1	3.1	14.4
392	Corn and Oat Provender	8.7	3.6	12
400	Corn and Oat Chop Feed	8.7	4.6	15.7
496	B Chop Feed	7	2.2	15.8
482	Arcade Mixed Feed	8.3	4.3	15.3
394	X Oat Feed	9.1	3.2	22.2
410	Vim Oat Feed	8	2.4	23.5
476	Golden Oat Feed	3.6	1.3	29.3
486	Royal Oat Feed	6.1	2.1	25
491	Dairy Feed	8.1	2.6	23

The hominy feeds shown above are certainly of a somewhat different grade from those heretofore examined at the Station and known to be pure, but whether this is due to processes of manufacture or to the deliberate introduction of inferior material does not appear from the chemical analysis.

It cannot be affirmed that all of the corn and oat feeds to which especial attention is called contain oat hulls. Some certainly do, but in a few cases the high proportion of fiber may possibly be due to the use of light oats, though this seems doubtful. The last five feeds mentioned in the last table consist wholly or very largely of oat hulls, and considering their real value they are sold at ridiculously high prices.

REPORT OF ANALYSES OF PARIS GREEN AND OTHER INSECTICIDES IN 1902.*†

L. L. VAN SLYKE AND W. H. ANDREWS.

SUMMARY.

In accordance with the provisions of a law designed to protect the purchasers of paris green, samples were secured during 1902 and the results are published in this bulletin.

In the 44 samples of paris green examined, the arsenious oxide varied from 55.39 to 61.40 per ct. and averaged 57.10 per ct. The water-soluble arsenious oxide varied from 0.61 to 1.35 per ct. and averaged 1.01 per ct.

The copper oxide varied from 27.03 to 30.79 per ct. and averaged 29.41 per ct. The amount of arsenious oxide in combination with copper varied from 50.63 to 57.60 per ct. and averaged 55.10 per ct. The general result of the examination is to show a good quality of paris green in the market at the time the samples were taken.

INTRODUCTION.

During the year 1902 there were collected for analysis 44 samples of materials sold as paris green, and also one sample of paragrene and one of aiboneta. The 44 samples of paris green represent 23 different manufacturers, 7 of whom were not represented in the samples examined by us in 1901.

For a discussion of the chemistry of paris green and for a statement of the methods of chemical analysis used see Bulletin No. 190, p. 284.

*Reprint of Bulletin No. 222.

†Printed by the authority and under the direction of the Commissioner of Agriculture.

ANALYSIS OF SAMPLES OF PARIS GREEN IN 1902.

No.	MANUFACTURER.	Total arsenious oxide.	Water-soluble arsenious oxide.	Copper oxide.	Arsenious oxide in combination with copper.
		Per ct.	Per ct.	Per ct.	Per ct.
108	Acme Color Works	56.86	1.23	30.66	56.86
375	Acme Color Works	56.86	1.35	29.79	55.81
369	Adler Color and Chemical Co	55.52	1.23	28.66	53.89
382	Adler Color and Chemical Co	56 25	1.35	29.79	55.81
387	Adler Color and Chemical Co	56.56	1.10	29.29	54.82
364	A. B. Ansbacher & Co	56.62	0.86	29.91	56.03
365	A. B. Ansbacher & Co	56.62	0.86	29.48	55.22
389	A. B. Ansbacher & Co	56.86	0.86	30.29	56.74
114	E. J. Barry	56.50	0.98	29.98	56.16
376	E. J. Barry	57.48	1.23	29.85	55.92
394	Lewis Berger & Sons	57.05	0.61	30.29	56.74
374	James A. Blanchard	58.15	0.86	28.72	53.80
377	James A. Blanchard	57.60	1.10	29.04	54.40
399	James A. Blanchard	55.76	1.35	29.10	54.51
111	George C. Buell & Co	55.82	1.35	28.29	52.99
373	Charles M. Childs & Co	59.87	0.98	27.41	51.35
392	Clark and Son	56.56	1.35	29.10	54.51
400	Franklin Chemical Co	57.35	1.35	29.79	55.81
381	Morris Herrmann & Co	59.50	0.98	28.04	52.52
367	Morris Herrmann & Co	60.78	1.10	27.35	51.23
390	Morris Herrmann & Co	61.40	1.10	27.03	50.63
370	Fred L. Lavanburg	57.05	0.86	29.66	55.56
386	Fred L. Lavanburg	56.37	1.35	30.10	56.37
106	George E. Laverack	55.95	1.23	29.73	55.69
107	George E. Laverack	55.39	1.23	28.98	54.29
110	Leggett & Bros	56.62	0.61	30.23	56.62
366	Leggett & Bros	59.01	0.86	28.60	53.57
378	Leggett a Bros	56.74	1.10	29.66	55.56
383	John Lucas & Co	56.62	0.98	30.48	56.62
397	John Lucas & Co	57.35	0.74	30.48	57.10
112	N. Y. Enamel Paint Co	56.62	0.86	29.41	55.09
368	I. Pfeiffer	56.25	0.98	29.85	55.91
396	I. Pfeiffer	56.86	0.86	29.66	55.56
398	I. Pfeiffer	56.93	0.74	29.85	55.91
109	C. T. Reynolds & Co	59.62	0.80	28.16	52.75
363	C. T. Reynolds & Co	60.48	0.74	27.91	52.28
372	C. T. Reynolds & Co	57.78	0.86	29.41	55.09
385	Salomon & Schwartz	57.42	1.35	30.48	57.10
371	Sondheim, Alsberg & Co	57.11	0.61	29.85	55.91
379	Stanley Jordan & Co	57.97	0.86	28.79	53.93
391	Towns & Wright	56.01	0.98	28.98	54.29
113	The Williams & Carleton Co	57.35	1.10	29.73	55.69
384	Unknown	56.99	0.74	30.66	56.99
395	Unknown	57.60	0.98	30.79	57.60
388	Paragrene, Fred L. Lavanburg	35.05	1.47	18.90	....

AIBONETA, manufactured by Schoonmaker & Son, Cedar-Hill-on-Hudson. Arsenious oxide, 4 50 per cent. Soluble arsenious oxide, none. Arsenic is present in form of lead arsenate.

DISCUSSION OF RESULTS OF CHEMICAL ANALYSIS.

1. *Total arsenious oxide.*— In the 44 samples of materials sold as paris green and examined by us the amount of arsenic equivalent to arsenious oxide varies from 55.39 to 61.40 per ct., and averages 57.10 per ct. So far as the total arsenic content is concerned, the amount found indicates a high quality of paris green. The variation is about the same as last year and, excepting four samples, is within surprisingly narrow limits. Were the total amount of arsenic present in paris green the only point to be considered, the quality would be regarded as very satisfactory, but we must consider at the same time the amount of water-soluble compounds of arsenic present in paris green.

2. *Water-soluble compounds of arsenic.*— The presence of water-soluble arsenic in paris green is seriously objectionable owing to the fact that soluble arsenic compounds injure foliage. Hilgard, of California, states that in the dry climate of California paris green injures foliage when it contains an equivalent of more than 4 per ct. of arsenious oxide in the form of soluble arsenic compounds. The water-soluble arsenic most commonly occurring in paris green is in the form of arsenious oxide, commercially known as common white arsenic.

The water-soluble arsenious oxide varies in the 44 samples of paris green examined from 0.61 to 1.35 per ct. and averages 1.01, which is far below the limit of harm prescribed for use as an insecticide and the limit fixed by law.

3. *Copper in paris green determined as copper oxide.*— The amount of copper expressed as the equivalent of copper oxide varies in the 44 samples of paris green examined from 27.03 to 30.79 per ct. and averages 29.41 per ct., which is about the same as in preceding years.

4. *Amount of arsenic oxide in combination with copper.*— The law relating to paris green in this State was amended in 1901 so as to correct certain defects existing in the original law with reference to the definition of paris green. The original law required that paris green should contain the equivalent of 50 per ct. of arsenious oxide. This provision was needlessly low, and was also open to the very serious objection that it per-

mitted indefinite adulteration by common white arsenic. This defect has been corrected by requiring that paris green shall contain arsenic *in combination with copper* equivalent to not less than 50 per ct. of arsenious oxide. In ascertaining the amount of copper in combination with arsenic it has been assumed that all the copper present was so combined, except when found in excess. While this assumption is not strictly accurate, it answers the purpose, especially when the precaution is taken to examine the paris green for water-soluble forms of copper compounds.

In the 44 samples of paris green examined the amount of arsenious oxide in combination with copper varied from 50.63 to 57.60 per ct. and averaged 55.10 per ct., which is about 5 per ct. higher than the minimum required by law. Only one sample fell below the limit, and this was only slighly below.

5. *General conclusion as to purity of paris green in market.*—Our results indicate a satisfactory condition as to the arsenic content of paris green found in the market during 1902, and the same can be said as to the amount of water-soluble compounds present in the samples examined.

APPENDIX.

I. Periodicals Received by the Station.

II. Meteorological Records.

Appendix.

PERIODICALS RECEIVED BY THE STATION.

Acker und Gartenbau Zeitung	Complimentary.
Agricultural Epitomist	"
Agricultural Gazette of New South Wales	"
Agricultural Journal and Mining Record (Natal)	"
Agricultural Journal of the Cape of Good Hope	"
Allegan Gazette	"
American Agriculturist	Subscription.
American Chemical Journal	"
American Chemical Society Journal	"
American Cultivator	Complimentary.
American Entomological Society, Transactions	Subscription.
American Fancier	"
American Fertilizer	"
American Florist	"
American Gardening	"
American Grange Bulletin	Complimentary.
American Grocer	"
American Hay, Flour and Feed Journal	"
American Journal of Physiology	Subscription.
American Monthly Microscopical Journal	"
American Naturalist	"
American Philosophical Society, Proceedings	Complimentary.
American Poultry Journal	"
American Stock Keeper	"
Analyst	Subscription.
Annales Agronomiques	"
Annales de l'Institut Pasteur	"

Annals and Magazine of Natural History.....	Subscription.
Annals of Botany...........................	"
Archiv der gesammte Physiologie (Pflueger)...	"
Archiv fuer Hygiene.........................	"
Association Belge des Chimistes, Bulletin.....	Complimentary.
Baltimore Weekly Sun.......................	"
Beet Sugar Gazette..........................	"
Beiträge zur Chemischen Physiologie und Pathologie	Subscription.
Berichte der deutschen botanischen Gesellschaft..................................	"
Berichte der deutschen chemischen Gesellschaft..................................	"
Biological Bulletin	"
Biologisches Centralblatt	"
Boletin do Instituto Agronomico do Estada de Sao Paulo	Complimentary.
Boletin de Agricultura Tropical.............	"
Boston Society of Natural History, Proceedings,	Subscription.
Botanical Department, Jamaica, Bulletin.....	Complimentary.
Botanical Gazette	Subscription.
Botanische Zeitung	"
Botanisches Centralblatt	"
Botaniste, Le	"
Breeders' Gazette	"
Buffalo Society of Natural Sciences, Bulletin..	Complimentary.
California Fruit Grower	Subscription.
Canadian Entomologist	"
Canadian Horticulturist	Complimentary.
Cellule, La	"
Centralblatt fuer Agrikultur-Chemie	Subscription.
Centralblatt fuer Bakteriologie und Parasitenkunde	"
Chemical News	"
Chemical Society, Journal..................	"
Chemiker Zeitung	"
Chemisches Centralblatt	"
Chicago Daily Drovers' Journal.............	Complimentary.

Chicago Dairy Produce	Complimentary.
Cincinnati Society of Natural History, Journal	"
Columbus Horticultural Society, Journal	"
Commercial Poultry	"
Country Gentleman	Subscription.
Country World	Complimentary.
Dairy and Creamery	"
Detroit Free Press	"
Edwards' Fruit Grower and Farmer	"
Elgin Dairy Report	"
Elisha Mitchell Scientific Society, Journal	"
English Catalogue of Books	"
Entomological News	Subscription.
Entomological Society of Washington, Proceedings	"
Entomologische Zeitschrift	"
Entomologist	"
Entomologists' Record	"
Fanciers' Review	Complimentary.
Farm and Fireside	"
Farm and Home	"
Farm Journal	"
Farm News	"
Farm Poultry Semi-Monthly	"
Farm, Stock and Home	"
Farmers' Advocate	"
Farmers' Call	"
Farmers' Guide	"
Farmers' Sentinel	"
Farmers' Tribune	"
Farmers' Voice	"
Feather	Subscription.
Feathered World	"
Florists' Exchange	"
Flour and Feed	Complimentary.
Fuehling's Landwirtschaftliche Zeitung	Subscription.
Garden	"
Gardeners' Chronicle	"

Gardening	Subscription.
Gartenwelt	"
Gleanings in Bee Culture	Complimentary.
Green's Fruit Grower	"
Hartwick Seminary Monthly	"
Hedwigia	Subscription.
Herd Register	Complimentary.
Hoard's Dairyman	"
Holstein-Friesian Register	"
Homestead	"
Horticultural Visitor	"
Hygienische Rundschau	Subscription.
Indiana Farmer	Complimentary.
Industrie Laitiere	"
Insect World	"
Ithaca Democrat	"
Jahresbericht der Agrikultur-Chemie	Subscription.
Jahresbericht Gärungs-Organismen	"
Jahresbericht der Nahrungs und Genussmittel	"
Jahresbericht Pflanzenschutzes	"
Jersey Bulletin	Complimentary.
Journal d'Agriculture Pratique	Subscription.
Journal of Applied Microscopy	"
Journal de Botanique	"
Journal of the Department of Agriculture of Western Australia	Complimentary.
Journal of Experimental Medicine	Subscription.
Journal fuer Landwirtschaft	"
Journal of Mycology	"
Journal of Physiology	"
Just's Botanischer Jahresbericht	"
Landwirtschaftlicher Jahrbuch	"
Landwirtschaftlichen Versuchs-Stationen	"
Louisiana Planter	Complimentary.
Meehan's Monthly	Subscription.
Milch Zeitung	"
Mirror and Farmer	Complimentary.
Monthly Weather Review	"

National Nurseryman	Complimentary.
National Farmer and Stock Grower	"
National Stockman and Farmer	"
Naturae Novitates	"
Naturaliste	Subscription.
Naturaliste Canadienne	"
Nature	"
Nebraska Farmer	Complimentary.
New England Farmer	"
New York Academy of Science, Annals and Transactions	Subscription.
New York Botanical Garden, Bulletin	Complimentary.
New York Entomological Society, Journal	Subscription.
New York Farmer	Complimentary.
New York State Granger	"
New York Tribune Farmer	"
North American Horticulturist	"
Northwest Horticulturist	"
Northwest Pacific Farmer	"
Oesterreichische Chemiker Zeitung	Subscription.
Ohio Farmer	Complimentary.
Ohio Poultry Journal	Subscription.
Operative Miller	Complimentary.
Pacific Coast Dairyman	"
Pacific Coast Fanciers' Monthly	Subscription.
Pacific Rural Press	"
Photo-Miniature	"
Photographic Times-Bulletin	"
Popular Agriculturist	Complimentary.
Poultry Herald	Subscription.
Poultry Keeper	Complimentary.
Poultry Industry	"
Poultry Monthly	"
Practical Poultryman and Poultry Star	"
Practical Farmer	"
Practical Fruit-Grower	"
Praktische Blätter fuer Pflanzenschutz	Subscription.
Progres Agricole et Viticole	"

Psyche	Subscription.
Queensland Agricultural Journal	Complimentary.
Reliable Poultry Journal	Subscription.
Republic	"
Revue Generale de Botanique	"
Revue Horticole	"
Revue Mycologique	"
Royal Agricultural Society, Journal	"
Royal Horticultural Society Journal	Complimentary.
Rural New Yorker	Subscription.
Salt Lake Herald	Complimentary.
Saint Louis Academy of Science, Transactions,	"
Sanitary Inspector	"
Science	Subscription.
Scientific Roll	"
Society of Chemical Industry Journal	"
Societe Entomologique de France, Bulletin	Complimentary.
Societe Mycologique de France, Bulletin	Subscription.
Southern Planter	Complimentary.
Southern Farm Magazine	"
Southwestern Farmer and American Horticulturist	"
Station, Farm and Dairy	"
Stazione Sperimentale Agrarie Italiane	"
Strawberry Specialist	"
Suffolk Bulletin	"
Sugar Beet	"
Texas Stockman and Farmer	"
Torrey Botanical Club, Bulletins and Memoirs,	Subscription.
Up-to-Date Farming and Gardening	Complimentary.
Utica Semi-Weekly Press	"
Wallace's Farmer	"
Watkins Review	"
West Virginia Farm Review	"
Western Fruit-Grower	"
Western Plowman	"
Woman's Home Companion	"

Zeitschrift fuer Analytische Chemie..........	Subscription.
Zeitschrift fuer Biologie....................	"
Zeitschrift fuer Entomologie.................	Complimentary.
Zeitschrift fuer Fleisch und Milch Hygiene....	Subscription.
Zeitschrift fuer Pflanzenkrankheiten..........	"
Zeitschrift fuer Physiologische Chemie........	"
Zeitschrift fuer Untersuchung der Nahrungs und Genussmittel........................	"
Zoologischer Anzeiger......................	"
Zoological Record.........................	"

METEOROLOGICAL RECORDS FOR 1902.

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1902.

DATE.	January.		February.		March.		April.		May.		June.	
	5 P. M. Max.	5 P. M. Min	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	6 P. M. Max.	6 P. M. Min.	6 P. M. Max.	6 P. M. Min.	6 P. M. Max.	6 P. M. Min.
1.	23.5	3.5	34	21	59	38	40	29	54	41	82	56.5
2.	37.0	9	36	26	46	34.5	40	32	61	34	82	63
3.	44	10	28	13.5	37	30	36.5	31	62	52	85	62
4.	16	8	13	6	32	22	42	30	70	49	76.5	59
5.	28	7	13	1	28	20	51	25	66.5	55	66	48
6.	32	16	24	—3	41	20	56	29	69	40	80	38
7.	34	21	23	11	51	30	48	33	*	54	78	62
8.	34	22.5	20	9	45	29	45.5	37	71	43	73½	51.5
9.	40	31	27	18	42.5	32	45.5	38	67	34	70.5	42
10.	38	31	24	13	43	31.5	42	35	45	27	68	55
11.	33	24	22.5	10	54	33	54	37	58	26	67	41.5
12.	25	11.5	25	13	66.5	44	49	35	64	32	75	57
13.	18	11	21.5	1	63	32	46	36	59	43.5	77	58
14.	28	11	23	12	43	25.5	46	34	58	31	81	57
15.	33	21	28	6	51	29	55	32.5	59	37.5	83	65
16.	32.5	22	33	—1	56	39	57	30	72.5	36	79	62
17.	26	8	30	15	52	29	57	39	72	45	68	50
18.	41	15	25	16	35	15	64	34	77	45	79	50.5
19.	41	17	19.5	7	28	14	63	43	77.5	56	79	59
20.	25	3	32.5	9	38	23.5	62	45	72	52	75	51
21.	32	18	31	16.5	41	32.5	63	40	73	36	69	54
22.	36	28	36	21	56	30	87	48	90	49	67	47
23.	33	23	40	12	55	36.5	83	53	87	65	64	44
24.	36	23	44	29	52.5	30	58	32	81	62.5	70	47
25.	39	14	44	31	50	25.5	53	28	79	57	74	45
26.	38	24.5	40	28	57	25.	73	45	73	57	68	53
27.	39	17	50	28	57	36.	65	39	67	45	68	51
28.	18	2	52	36.5	57	43.	70	36	47	35	74	53
29.	19	6	......	......	66	45.	67	44	64	35	68	54
30.	23.5	10	......	......	57	37.	72.5	52	64	52	62	47
31.	22	4	......	......	50	32.	......	......	79	45	......	......
Average	31.1	15.2	30.	14.5	48.7	30.4	56.4	36.7	67.9	44.2	73.6	52.8

*Thermometer heated by the burning of the barns.

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1902—(*Concluded*).

DATE.	July. 6 P. M. Max.	July. 6 P. M. Min.	August. 6 P. M. Max.	August. 6 P. M. Min.	September. 5 P. M. Max.	September. 5 P. M. Min.	October. 5 P. M. Max.	October. 5 P. M. Min.	November. 5 P. M. Max.	November. 5 P. M. Min.	December. 5 P. M. Max.	December. 5 P. M. Min.
1	76	53	85.5	67	90	69.5	67	56	58	31	41	26
2	77	55	85	61.5	80	63	59	50	66	40	52	33
3	75	61	87	59	84	49	64	47	63	47	51	38
4	83.5	62	81	64	80	55	60	44	60	32	45	29
5	83	63	82	54	64	45	64	51	64	45	30	17
6	84	66.5	80	64	74	40	64	51	62	54	28	13
7	86	65	74	56	79	56	65	46	56	41	35	19
8	88.5	65	72.5	57	84	51.5	64	42	50	25	31	10
9	88.5	63	77	55	74	57	62	45	60	28	13.5	—5
10	80	63	76	56	67	47	60	29	55	37	37	5
11	80	55	78.5	67	79	46	60	44	43	26	37	16
12	80	55	72	52	80	50.5	60	51	71	39	30	14
13	85	55.5	74	47	75	55	70	51	72	43	16	5
14	90	62	80	51	65	42	64	44	73	53	20	11
15	87	†	75	57	68	38	56	35	64	51	26	.02
16	78	58	71.5	52	74	43	55	43	53	45	42	25
17	86	56	75	50	73	45	50	30	46	41	38	26
18	82	63	78.5	59	72	46	55	29.5	53	45	36	26.5
19	71.5	60	72	60	75	56	74	51	56	46	44.5	27
20	67	62	75	51	79	50	57	40	56	34	39	19
21	78	60	75	61	79	60	51	35	59	40	39	28
22	74	59	69	53	76	61	62	29	59	43	43	33
23	84	54	73.5	56	83	58	57	45	47	32	34	20
24	79.5	60.5	75	56	76	54	62	41	50	33	30	13
25	79	55	80	54	57	47	69	43	50	34	30	17
26	82	62	82	55	69	53	59	35	37	27.5	26	17
27	90	66	79	59	76.5	61	64	52	44	33	22.5	15
28	85	68	80	55	73	60	56	45	38	26	28	10
29	82.5	65	83	59	69	59	45	33	41	22	33	14
30	85	65	86	60	70	58	54	29	42	35	35	14
31	85.5	67	90	58	......	......	54	43	......	......	36	.06
Average	81.7	60.8	78.2	57	74.8	52.5	44	42.2	54.9	37.6	33.8	17.5

†Thermometer out of order.

AVERAGE MONTHLY TEMPERATURE SINCE 1882.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1883	17.4	22.3	23.6	43.3	52.0	66.6	67.4	65.6	56.3	46.6	39.1	27.5
1884	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	36.5	27.2
1885	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.0	58.3	49.2	39.3	27.8
1886	19.6	22.9	30.2	48.1	55.7	64.0	68.0	67.5	61.8	49.6	36.8	22.2
1887	20.2	23.2	26.3	41.1	62.5	65.7	75.6	66.5	57.7	47.0	37.6	27.6
1888	16.4	22.8	24.6	40.8	54.3	66.5	66.8	68.0	62.2	43.9	39.4	29.3
1889	29.1	18.1	33.9	45.1	58.4	65.3	70.2	66.0	60.5	44.0	40.3	35.2
1890	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4
1891	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.3	38.4	35.5
1892	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.2	50.0	35.9	25.2
1893	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5
1894	29.7	20.6	38.9	44.1	55.5	67.8	74.2	66.8	64.9	52.7	36.0	31.5
1895	21.8	16.9	26.9	44.4	59.0	......	......	71.2	61.7	45.4	39.6	31.4
1896	22.4	24.1	24.4	49.3	62.0	65.9	71.4	70.0	60.2	56.5	42.9	27.1
1897	23.2	26.1	33.8	45.0	55.4	62.3	73.6	67.6	62.3	52.6	39.7	29.2
1898	26.2	26.8	......	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9
1899	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.5	38.9	30.0
1900	26.0	22.6	23.6	43.5	56.7	68.4	72.6	74.1	66.1	57.9	41.1	28.7
1901	26.1	18.5	32.2	46.5	56.9	68.9	76.6	71.0	64.0	51.4	34.3	27.7
1902	23.2	22.2	39.5	46.6	56.1	63.2	71.2	67.6	63.6	43.1	46.3	25.7

PRECIPITATION BY MONTHS SINCE 1882.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1882	....	....	....	....	....	3.69	2.42	2.37	1.25	0.62	1.22	0.55	.....
1883	0.48	1.44	0.88	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.54	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.49	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.64	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.79	3.48	1.24	27.87
1887	0.18	2.97	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	3.88	0.99+	4.02	2.73	3.47	2.02	1.24+	27.48
1889	2.99+	0.25	0.66+	3.28	1.21	7.47	4.57	1.98	2.50	3.32	3.44	1.62	32.28
1890	2.16	1.45	2.16	2.20	5.49	5.26	1.07	4.34	5.81	4.54	2.40	....	36.88
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	2.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	1.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	3.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.64	3.59	0.43	0.47	29.36
1895	0.96	....	0.29	1.36	2.88	....	....	2.66	0.94	0.72	2.31	2.49	.....
1896	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.64	0.21	2.12	1.90	2.19	3.16	5.28	1.27	2.36	0.73	2.53	1.39	23.78
1898	1.74	0.33	1.54	2.03	1.90	2.37	1.32	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35
1900	1.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	3.65	6.13	0.78	27.73
1901	0.72	....	2.19	4.43	3.80	2.07	3.97	5.52	2.46	1.35	2.09	3.37	31.97
1902	0.86	0.66	1.94	1.92	2.84	4.33	5.25	2.41	2.88	2.32	0.74	0.74	26.89

WIND RECORD FOR 1902.

DATE.	January. Northerly, N. W. to N. E.	January. Easterly, N. E. to S. E.	January. Southerly, S. E. to S. W.	January. Westerly, S. W. to N. W.	February. Northerly, N. W. to N. E.	February. Easterly, N. E. to S. E.	February. Southerly, S. E. to S. W.	February. Westerly, S. W. to N. W.	March. Northerly, N. W. to N. E.	March. Easterly, N. E. to S. E.	March. Southerly, S. E. to S. W.	March. Westerly, S. W. to N. W.	April. Northerly, N. W. to N. E.	April. Easterly, N. E. to S. E.	April. Southerly, S. E. to S. W.	April. Westerly, S. W. to N. W.	*May. Northerly, N. W. to N. E.	*May. Easterly, N. E. to S. E.	*May. Southerly, S. E. to S. W.	*May. Westerly, S. W. to N. W.
	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.	Hrs.
1			2	21		7	14		1		13	2			2	21			2	18
2			12	12		14	1	9	1		1	16				24		8	16	
3				24			2	22				24				24	5	2	7	3
4			7	12			10	14				19			1	4		5	19	
5			3	17				14	16				6		2	5	1		4	13
6			24				10				7	16		6	13	2				
7		4	13				6	18			12	2		12	6					
8		9	7					24	1	11		2	14	10						
9		6	9					24				16	19	3		2				
10	2		1	19				24		5	4	12				17				
11			14	8			3	21			24			2	1	15				
12				24			17	5			24				2	22				
13				24	3		4	17	3		8	13				24				
14			10	12			5	16	11			2				23				
15			12	12			1	4		19	4		2		1	16				
16			5	15		1	5	1		8	14	2		6	6	7				
17			12	8			4	19				24	1	2		16				
18			13	11				24				24		7	2					
19				20				24				24		6	13	3				
20		5	2	2			6	6				24	2		8	7				
21	11	9	4		5	10	3					19		10	4					
22	13			11			6	15	5			13			4	16				
23				24			5	1	4			20				20				
24				20		2	14	1	8			16				19				
25		5		4	4			4	8			6		12	7	1				
26		9	15		5			10		9	1	1		4	9	11				
27			2	22		9	1	1		7	17					24				
28				24	1	17	3	1		10	14			7	2	8				
29		9	3	5						7	5	12		8	16					
30	4	1								5	4	12		1	9	14				
31		10	12	2						2	11	8								
Total hours of movement	30	67	182	353	18	60	120	319	58	83	163	329	44	96	108	345	6	15	48	34
Percentage of time in each direction	4.7	10.6	28.8	55.9	3.5	11.6	23.2	61.7	9.2	13.1	25.7	52.0	7.4	16.2	18.2	58.2				

*Instruments destroyed by fire May 7th, 1902.

SUMMARY OF DIRECTION OF WIND FOR 1902 UP TO MAY 1ST.*

	Northerly, N. W. to N. E.	Easterly, N. E. to S. E.	Southerly, S. E. to S. W.	Westerly, S. W. to N. W.	Total.
	Hours.	Hours.	Hours.	Hours.	Hours.
January	30	67	182	353	632
February	18	60	120	319	517
March	58	83	163	329	633
April	44	96	108	345	593
Total hours of movement	150	306	573	1,346	2,375
Percentage of time in each direction	6.3	12.9	24.1	56.7	....

* Instrument burned with barn May 7th.

READINGS OF THE STANDARD AIR THERMOMETER.

1902.	January.			February.			March.			April.			May.			June.		
	7 A. M.	12 M.	6 P. M.	7 A. M.	12 M.	6 P. M.	7 A. M.	12 M.	6 P. M.	7 A. M.	12 M.	6 P. M.	7 A. M.	12 M.	6 P. M.	7 A. M.	12 M.	6 P. M.
1........	5	13	12.5	26	30	34	40	54.5	46	33	37.5	38	43	46	49	61	77	79
2........	23	31	36	33	34	27	36	39	35	34.5	40	34	39.5	58	61	71	80	80
3........	17	15	11	16	18	14	32	34.5	31	33	35	35	53	58.5	55	75	74	76
4........	9.5	14	11.5	7	12	13	23	28	26	32	37	39	51.5	61	66	66	65	60
5........	24	27	27	2	11	12	23	27	26	32	48	45	59	58	64	55	65	62
6........	18	29	31	1	22	18	21	33	38	35	53	46	47	62	57	52	71	76
7........	22	29	29	20	21.5	17	36	47	45	35	47	45	*	63	55	65	71	73
8........	29.5	32	33	11	18	19	31	37	42	42	38	42	53	67	67	56	57	55
9........	33	39	35	22	26	23.5	36	33	35	40	43	41	40	41	44	52	63	68
10........	35	35	32	15.5	15.5	13	33	39	42.5	37	38	41	32	41	41	57	63	61
11........	29.5	29	24	12.5	19	18	38	51	49.5	42	52	46	41	53	51	53	61	67
12........	21	19	12	16.5	22.5	21	49	62	62	43	45	45	42	62	53	67	74	70
13........	12	14.5	17	15	18	15	47	42	33	39	41	43	47	58	53	65	74	74
14........	17	26	28	14	20	19	29	39	42	36	36.5	44	46	56	53.5	61	77	73
15........	27	30	32	14	23	22.5	38	48	50	37	53	48	45	55	55	68	80	79
16........	29	30	23	4	28	29	46	56	50	38	53	52	50	68	67	70	79	67
17........	8.5	21	18	19	25	21	31	33	34	40	56	52	52	66	67	55	63	68
18........	26	32	40	20	20	17	17	23	19	41	58	58	54	72	72	63	74.5	78
19........	20	21	17	8	15.5	17	16	19	27	46	60	53.5	59	76	72	60	72	74
20........	5	21	22	10	27	27	26	33	35	48	56	55.5	53	62	64	59	65	68
21........	29	32	28.5	25	29	29	34	39	41	45	57.5	57	51	66	70	58	63	66
22........	33	33	33	22	33.5	31	37	52	52	73	79	83	60	79	87	57	60	58
23........	24	27	27	15	34	36	39	53	51	63.5	73	53	71	83	73	51	62	56
24........	25	31	31	30	38.5	40	33	43	41	43	53	48	69	68	79	56	67	56
25........	23	35	30	33	40	39.5	30	48	45	39	49	51	69	69	66	57	71	68
26........	32	35.5	37	31	36	35	32	51	56	55	62	64	62.5	71	66.5	54	63	61
27........	34	23	17	30	47	45	40	50	52	41	45	54	50	52	46	54	62	66
28........	3	10.5	10.5	44	50	45	44	54	53	45	68	66	37	40	41	59	70	68
29........	9	16	16	......	......	......	55	65	49	52	59	53	46	60	60	55	58	56
30........	10	22	18	......	......	......	40	52	49	57	70	54	62	55	54	56	59	59
31........	14.5	22	22	......	......	......	36	42	34	......	......	......	49	70	76.5	......	......	......
Average.	20.9	25.6	24.5	18.4	26.2	24.9	34.5	42.8	41.6	42.6	51.4	49.5	51.1	61.3	60.8	59.6	68.0	67.4

* Thermometer heated by burning of the barn.

READINGS OF THE STANDARD AIR THERMOMETER — (*Concluded*).

	July.			August.			September.			October.			November.			December.		
	7 A.M.	12 M.	6 P.M.	7 A.M.	12 M.	6 P.M.	7 A.M.	12 M.	6 P.M.	7 A.M.	12 M.	6 P.M.	7 A.M.	12 M.	6 P.M.	7 A.M.	12 M.	6 P.M.
1	53	70	74	72	75	75	72	78	78.5	62	64.5	57	31	54	53	31	39	36
2	67	74	73.5	70	79	81.5	65	72	73	52	56	57	42.5	59	61	40	48	43
3	66	75	72	72	82	78	59	76	80	52	63	59	48	53	52	42	49	54
4	71	80	80	68	75	75	59.5	68	61	50	58	58	35	55	54	31	31	29.5
5	69	80	77.5	66	76	80	49	60	61.5	55	61	63	47	60	59	21.5	20	18
6	69	75	81	67.5	73	68	49	68.5	71	53	55	61	58	60	55	16.5	25	21
7	71	79	81	60	68	68	61	67	75	53	63	53.5	42.5	44	41.5	29	34	30
8	76	87	87	61	66	70	58	79	78	43	55	62	26	45	44	24	17	10
9	72	76	79	61	73	72	73	75	58	48	50	46	30	52	50	—4	5	7
10	65	70	71	65	72	72	53	61	67	32	52	57	54	51	43	24	35	36
11	63	75	76	73	67	71	53	75	75	48	59	57	28	42	41	24	23	17
12	61	77	77	56	65	66.5	58	73	75	54	57.5	58	54	70	66	26	19	14
13	67	81	81	57	71	67	58	59	59.5	56	65	62.5	44	63	63	13	14	13
14	67	87	87	58.5	72	74	47	58	63	45	46	46	57	70	64	13	17	11
15	70	76	77.5	61	73	68	48	64	65	40	56	54	54	62	52.5	14	23	26
16	58	68	70	60	69	71	47	70	71	48	47.5	43.5	45	46.5	45	39	42	36
17	65	75	81	57.5	70	72	52	70	69	30	47	46	43	44	46	28	33	31
18	66.5	68	71	62	76	66	50	67	69	43	50	54	48.5	52	49	33	35	33
19	61	65	67	62	65	68	58	73	72	55	69	66	48	51	50	35	44	38.5
20	63	65	65	60	73	69	53	71	76.5	42	56	50	35	52	48.5	21	29	29
21	69	77	68	68	73	68	65	76	76	38	44.5	42	53	56	51.5	38	38	39
22	60	67.5	72	59	67	61	64	71	75	34	53	57	48	56	45	39	39	33
23	66	80	79	60	71.5	72	62	77	75	50	48	46	33	37	36.5	20	24	20
24	63	68.5	66	60	71	73	55	58	57	52	58	62	46	49.5	49	16	26.5	29
25	63	75	76	64	76.5	77	52	53	55	49	47	44	34.5	40	37	28	27	17
26	68	76	78	62	77	79	59	69	64	44	52	53	31	33	33	19	26	22
27	69	83	84	65	74.5	71	62	73	72	57	60	55	40	43.5	37	19	20	15
28	69	75	78	60	74	74	64	65	60	46	52	45	27	30	30	17	27.5	24
29	67	78	78	63	77	80.5	62.5	65	67	34	37	36	28	40	39	24	39	33
30	68	79	83	66	79	84	62	69	86	31.5	42	53	36	38	36	18	32	29
31	73	84	84	66	82.5	88	......	......	......	44	49	46	......	......	......	14	31	27
Average	66.3	75.7	76.6	63.3	73.0	72.9	57.7	69	68.8	46.5	54	53.2	41.6	50.3	47.7	24.3	28.9	26.2

Summary of Maximum, Minimum and Standard Air Thermometers.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Maximum	31.1	30.0	48.7	56.4	67.9	73.6	81.7	78.2	74.8	44.0	54.9	33.8
Minimum	15.2	14.5	30.4	36.7	44.2	52.8	60.8	57.0	52.5	42.2	37.6	17.5
Standard, 7 A. M.	20.9	18.4	34.5	42.6	51.1	59.6	66.3	63.3	57.7	46.5	41.6	24.3
Standard, 12 M.	25.6	26.2	42.8	51.4	61.2	68	75.7	73.0	69	54.0	50.3	28.9
Standard, 5 P. M.	24.5	24.9	41.6	*49.5	60.8	67.4	*76.6	*72.9	68.8	53.2	47.7	26.2

*Taken at 6 P. M.

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V.

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